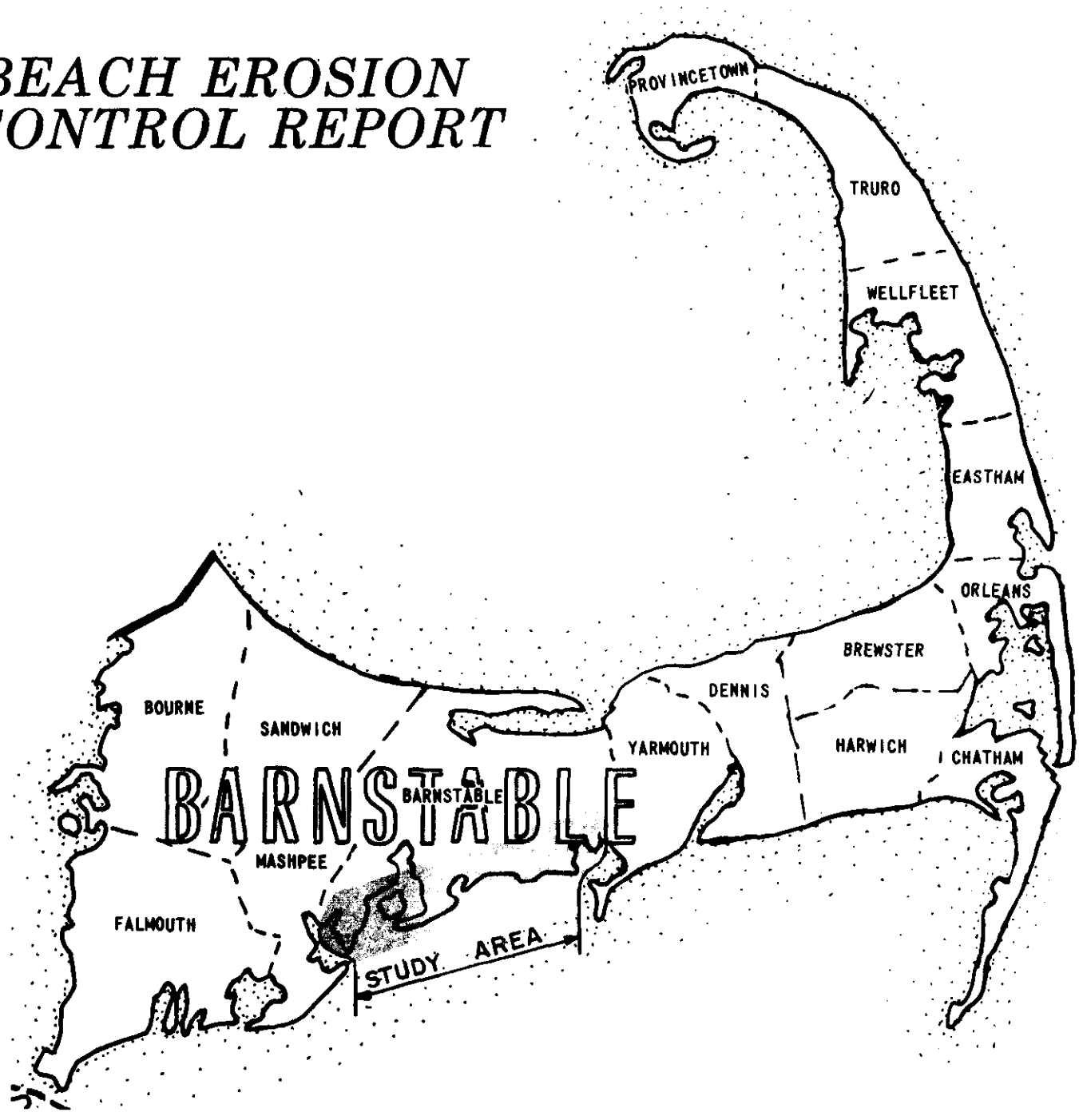
BEACH EROSION CONTROL REPORT



SOUTH SHORE OF BARNSTABLE
MASSACHUSETTS
FEBRUARY 1977

SYLLABUS

The study covers the shorefront of the south side of the town of Barnstable on Cape Cod, extending from the Mashpee town line on the west extremity to the Yarmouth town line on the east, a total of 12 miles. Its purpose is to investigate feasible methods of controlling erosion of the shorefront, which includes public beaches as well as adjacent privately owned shores.

The Division Engineer has studied the erosion problems along the 12-mile shorefront and has found that the public beaches in the study area are in reasonably satisfactory condition and that typical erosion control measures such as sandfill, riprap revetment, groins, and jetties for these beaches cannot be economically justified. However, erosion control plans have been developed, for possible implementation by local interests, for the protection and restoration of privately owned shores. These are discussed in the report.

The Division Engineer, therefore, recommends no Federal participation in erosion control projects for public along the south shore of Barnstable at this time.

The Division Engineer does recommend that erosion control measures for privately owned shores, which may be undertaken by local interests based upon a determination of their economic and environmental justification, be accomplished in accordance with plans and methods developed in the report. Further, non-structural measures such as zoning regulations, building codes, flood-proofing of structures, dune grass planting, sand fencing, and other allied methods should be considered.

SOUTH SHORE BARNSTABLE, MASSACHUSETTS
BEACH EROSION CONTROL REPORT

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THE STUDY AND REPORT

Coastal shorelines have always had an appeal to man, as a place of domicile because in general the view of the nearby water contributes greatly to his pleasures of life. Along the Atlantic coast beautiful beaches and tidal inlets serve to enhance a way of life. However, these beach and headland habitats are limited from the standpoint of natural resources and are difficult to retain or replace. Loss of these resources is generally attributed to storms which buffet the coastline resulting in human misery and damage to property. These factors of coastal erosion and structural damage from storms affect the entire south coast shoreline of Barnstable, Massachusetts.

Proper solution to the shoreline problems presented, require systematic and thorough study. The first requisite for such study is a clear definition of the problems and the objectives sought.

Ordinarily there will be more than one method of obtaining the objectives, so the immediate and long term effects of each method should be evaluated not only in the immediate problem area, but also for adjacent shore areas. All physical and environmental effects, advantageous and detrimental, should be considered in comparing annual costs and benefits to determine the justification of protection methods.

Authority and Purpose

Because erosion was threatening developments along the south shore of the Town of Barnstable, local interests sought aid in combating the problem from their representatives in Congress. As a result of these requests for help, the Committee on Public Works of the United States House of Representatives adopted a resolution on 11 December 1969, requesting that the Secretary of the Army direct the Chief of Engineers to make a survey of the shores of the Town of Barnstable in the interest of beach erosion control and related purposes.

The study was made to determine (1) the most suitable methods for stablizing and improving the southern shoreline of the Town of Barnstable; (2) which sections of the shore are desireable locations for shoreline improvements and the most effective methods for accomplishing the improvements, and (3) the economic justification for providing protective and improvement measures.

Scope of Study

The study, as presented in this report, encompasses the 12 miles of coastline along the southern shore of Barnstable between the towns of Mashpee on the west and Yarmouth on the east. The entire shorefront is exposed to wave action and tidal flooding from the southerly quadrants. Because of irregularties, some sectors of the shoreline are more susceptible to wave action than others. However, each sector was investigated in detail. Beach profiles and nearshore sounding surveys were made in some of the sectors. Wave refraction and diffraction studies were conducted in the areas where severe erosion was indicated. All problems were investigated and possible corrective measures considered.

Study Participants and Coordination

At the local government and private level, the following have had a role in this study: The Board of Selectmen of the Town of Barnstable, the Town's Waterways Committee, the Committee to Study Erosion of Long Beach, the Craigville Beach Erosion Committee, the Centerville Civic Association Beach Erosion Committee, and various individual shorefront property owners. At the state level, the Division of Waterways, Department of Environmental Quality Engineering, was contacted to obtain information on dredging, jetty construction and other work the department had done along the shores in question. The Coastal Engineering Research Center, a research arm of the Corps of Engineers in Fort Belvoir, Virginia, was asked to provide all available maps and information concerning shoreline changes on the south shore of Barnstable.

The Report

In the interest of clarity of presentation and reference, the report has been divided into a main report with two appendices. The main report is a general non-technical summary giving the results of the study for the entire south shore of Barnstable. It is the basic document presenting a broad view of the study for the benefit of all readers, both technical and non-technical. It discusses and analyzes the problems, the desires of local interests for improvements and possible solutions. The appendices to the report present background supporting data and technical detailed analysis covering the features of the study:

Appendix A - Discusses the design analysis and gives detailed estimates of the cost of improvements.

Appendix B - Contains pertinent correspondence.

Prior Studies and Reports

There has been no specific prior report on beach erosion control within the study area. However, a beach erosion control report was completed in 1941 covering the shores extending from Chatham on the west to Point Gammon located just south of Lewis Bay. The report was prepared by the Beach Erosion Board (Now the Coastal Engineering Research Center). This report broadly discusses the geology, erosion processes, problems encountered within the report area and suggests practical methods of erosion control as a guide for use by the Commonwealth of Massachusetts and local municipalities for developing and improving the shorefront area under study.

Navigation improvements have been the subject of studies within the area covered by this report. Reports have been made for Hyannis Harbor, Cotuit Harbor, and Popponesset Bay. As a result of the Hyannis study, a navigation improvement project was completed in 1959. The existing project provides for a channel 12 feet deep at mean low water leading from deep water in Nantucket Sound to the Town Wharf in Lewis Bay; an anchorage area of the same depth in the inner harbor at Hyannis; a 15 foot deep anchorage in the outer harbor, protected by 1,170-foot long breakwater and a rip rap jetty extending southward from Dunbar Point for a distance of 1,000 feet.

At Cotuit Harbor, a navigation improvement project was adopted in 1960 which provides for dredging an entrance channel 10 feet deep at mean low water leading from Nantucket sound into West Bay; a channel 8 feet deep 1.8 miles long, from the West Bay entrance through the bay and the bridge at Osterville and into Great Bay; a channel 8 feet deep,

1.6 miles long from the West Bay entrance through Seapuit River into Cotuit Bay. No construction work has been done on this authorized project. The project was authorized provided that, prior to construction, local interests agree to:

a. Contribute in cash 50 percent of the cost of construction;

b. Provide without cost to the United States all lands, easements, rights-of-way, and suitable disposal areas for the dredged materials resulting from the construction and maintenance of the project;

c. Hold and save the United States free from damages due to the construction and maintenance of the project;

d. Provide and maintain two suitable public landings with adequate berths in accordance with plans approved by the Chief of Engineers, open to all on equal terms; and

e. Maintain the jetties at the entrance to West Bay.

In January 1962, formal assurances of local cooperation were forwarded to the State of Massachusetts and the Town of Barnstable for execution. At a Town Meeting held on 6 March 1962 the townspeople voted not to participate in the Cotuit Harbor navigation improvement project. In view of the action by the Town of Barnstable, the State of Massachusetts, advised that the assurance agreement could not be executed. Pending renewed interest and compliance with the requirements of local cooperation by local interests the Federal project for navigation improvement of Cotuit Harbor was placed in the inactive category.

A navigation improvement survey report on Popponesset Bay was completed in June 1972. The report found that there is a need for recreational boating improvement. However, the cost of any considered improvement would exceed the anticipated benefits and as a result no plans could be economically justified for Federal participation in a navigation project.

RESOURCES AND ECONOMY OF STUDY AREA

Environmental Setting and Natural Resources

Although the immediate study area only encompasses the shoreline of the south coast of Barnstable, the adjoining area of the town must be considered in the development of solutions to the erosion problems. The Town of Barnstable is located midway along the southern arm of Cape Cod. It is bordered on the west by the Towns of Mashpee and Sandwich, on the north by Cape Cod Bay, on the east by the Town of Yarmouth and on the south by Nantucket Sound. The coastlines are irregular, containing many indentations. Several small rivers drain the interior portions of the town flowing into the study area facing Nantucket Sound. These rivers from west to east are, Mashpee, Santuit, Mills, Bumps, and Centerville. All of them have small drainage areas.

The existing land form is primarily the result of the action of glaciers which deposited sand, clay, gravel and boulders at the limit of their southward advance across New England. The two major land types

formed by the glaciers were moraines and outwash plains. The moraines formed a line of irregular hills rising above the surrounding land, interspersed with hollows, called kettle holes. These holes were formed by the melting of isolated blocks of very hard ice from which the glacier itself had melted away. When these ice foundations finally melted, the land sank, forming pockets into which the ground water promptly seeped. These water pockets are today the ponds that are found scattered thickly over the whole length and breadth of the Cape. The moraines formed the present day belt of highlands running along the northern shore of Cape Cod from the Canal to the ocean at Orleans.

The second formation which comprises most of the land form within the study area consists of an outwash plain which spread down from the moraines forming a broad sweeping stretch, extending offshore into Nantucket Sound. This outwash plain was formed by streams flowing out from under the face of the glaciers. These rivers forced their way through the debris deposited in front of them, carrying the lighter material along, spreading it out in a broad gentle slope that forms the present day southern shore of the Cape. After the glaciers melted the more exposed coast from Provincetown to Monomoy Point was smoothed out by strong tidal currents and wave action, while the southside of the Cape remained ragged and notched with shapeless coves and sand spits.

Erosion of the outer face of the outwash plain formed barrier beaches which in turn provided calm waters behind the beaches. As soon as the beach had grown long enough to provide calm water,marshes began to form, spreading slowly or fast, depending upon the proportion of mud and sand deposited. The large marsh areas within the south side of Barnstable were formed in this manner.

When settlers first appeared in Barnstable about 1638, the entire inland area was heavily wooded with a wide variety of trees. Even the sand hills of Provincetown were covered with a layer of good soil that supported considerable vegetation. Those trees bore little resemblance to the scrub pine and oak that today comprise the vegetative cover. All of the towns used this seemingly inexhaustable supply for both building and fuel until the end of the seventeenth century. It can be concluded that the first settlers demolished the timber wholesale. This ruthless treatment of the land which resulted in ruining the soil, drove the Cape Cod farmer to sea to earn a livelihood.

By the end of the eighteenth century the landscape had been changed to such an extent that the harvesting of salt marsh hay and operating salt works had become the chief methods of earning a living from the land, and the Cape had largely become a maritime region. Fishermen, whalers and coastwise trading vessels commanded the harbors along the shore. The next great industry on the Cape was ship building. However, by the end of the Civil War the fishing industry had deteriorated to the extent that many families left the Cape to settle in regions closer to the fishing grounds, such as Nova Scotia. Likewise, whaling had diminished to the extent that those in the trade moved off the Cape to more lucrative centers for the trade. By 1857, local newspapers reported that only two or three fishing vessels operated out of Yarmouth where formerly 20 or 30 sail vessels were employed.

With the loss of local fishing as a major industry clamming became a means of livelihood. A hundred years ago the clam-digger was usually a veteran of the fishing fleet on the Banks who had grown too old to stay at sea.

For the past thirty years clamming has been the chief industry in Barnstable that has taken men off dry land. Hundreds of acres of flats were exploited reaching the peak of the boom in 1925, before the selectmen realized the danger of extermination and refused to renew grants that had expired. However, the measure has protected the supply. Native oysters from Cotiut Bay were also harvested during this period and shipped throughout the country.

The above brief geological and historical summary of the Cape in general was necessary to help establish a better view of the needs for this study. It points out the facts that the basic materials in the area are composed of loose glacial origin intermixed with fine grained top-soil or silt which washed into the fore shore areas following the removal of the original forest vegetation. Economic changes moved the population into a closer proximity to the shore which in turn has caused a greater awareness for the needs to preserve the fragile resources of the study area.

Human Resources

What has happened on the Cape since the early thirties has set the character of its relationship to the world. The Cape was not easily reached from the outside until the Old Colony Railroad was constructed. Within the last twenty years this railroad has been supplanted by a network of expressways and secondary roads. Interstate Routes 95 and 195 connect from New York to New Bedford, Massachusetts. State Routes 3 and 6 cross the Cape Cod Canal by way of the Sagamore and Bourne Bridges respectively. Route 6 known as the Mid-Cape highway crosses

through Barnstable just north of the study area. This highway as well as the others previously mentioned are limited access highways which have cut travel time to a considerable extent. In the 1920's a trip by car from Boston took most of the day. At present the cape is only an hour and a quarter from Boston and about five hours from New York. Hyannis airport is the principle air terminal on the lower Cape Cod. During the decade of 1960 to 1970 the permanent population of Barnstable increased 47.4% from 13,465 to 19,842. In the previous decade 1950 to 1960 the population increase amounted to 28.6% and in the 1960's was projected to increase to 22,000 by 1980. However this projected increase for twenty years was almost a reality in ten years.

In order to show the effect that improved highway systems have had on the town of Barnstable the summer resident population growth of the town has been estimated, taking into consideration such influences as the existing population rate of growth, the attractions of the National Seashore Park, new town owned beach access and enlarged state parks. Barnstable summer residents numbered 15,513 in 1960 and the projected increase by 1980 is approximately 35,000 people for a 110 percent increase.

Development and Economy

Tourism is the mainstay of the region, as well as new developments to attract retired people, commuters and a growing number of men and women employed in service industries.

Agriculture as previously mentioned has declined from its primary role. Most farms are not commercial farms but only serve to supplement other income sources. However, ornamental horticulture is a growing segment

of the agriculture economy as a result of the new wave of residential construction.

The Cape is not in a competitive position in manufacturing because of a lack of a concentrated labor market and the proximity of industrial centers at Fall River, New Bedford and Boston. Most of the workers in manufacturing employed on Cape Cod are in printing, boat building and candle making.

According to information from the Massachusetts Department of Commerce, per capita income on Cape Cod is less than that in Massachusetts but is about equal to the United State, which means that the income of year-round residents is substantially lower than that of near-by manufacturing areas in Massachusetts.

The most important economic asset of the Town of Barnstable is its attraction as a summer resort. The area attracts three distinct categories of visitors; summer residents, who occupy a seasonal dwelling or cottage for longer than two weeks constitute the largest segment of the Cape's visitor activity. It is estimated that there were 126,000 summer residents on the Cape in 1960, by 1980 there will be about 237,000 summer residents on Cape Cod. From the local point-of-view, summer residents are valuable because they pay taxes but do not require schools. The second category of visitors are those who use overnight facilities from one night to two weeks. These visitors occupy commercially managed, furnished cottages, hotels, motels and campsites. Since many of these vacationers return year after year to the same spot, they are very similar to the summer residents in that they support the same recreational facilities and commercial establishments. These visitors usually locate

close to marinas, harbors, beach and golf course attractions. The third group are weekenders or day trippers spending a night or two on the Cape sight-seeing. The weekenders are a valuable asset to the local economy. These short term visitors require a minimum of personal or municipal services such as supervising, policing and cleaning of public beaches which form their greatest attraction to the area. Direct access to the day trippers' recreation spot is important to him. He has not much time to spend and he wants to spend as much as possible at play. He will demand good highways, free from local traffic, and only as he approaches his destination will he be willing to switch to secondary roads. Thus, the town of Barnstable with its attractive public beaches, located midway on the Cape, is a potential site for increased short term tourism, provided the beaches are adequate and well maintained.

PROBLEMS AND NEEDS

The problem consists of continuous erosion of bluffs and beaches along the southerly shore of Barnstable. The erosion is caused by severe wave action and high tidal surges accompanying hurricanes and more frequent storms of lesser magnitude but of longer duration than hurricanes. To combat the erosion and to provide protection against flood damage the state, town and private interests have individually constructed numerous groins, jetties, stone mounds, walls, and revetments to protect beaches, roads, cottages, year-round residences and various inlets. This haphazard procedure in combating the erosion and flooding problems has in recent years caused local residents to form various committees to study

the problem of protection. These studies have concluded that a comprehensive master plan is needed to control the hit or miss approach of the past, where individuals have attempted to provide their own protection to the detriment of others. As a result, these study committees have petitioned the town to conduct a comprehensive study which would provide recommendations and guidelines for beach erosion control.

Improvements Desired

A public hearing was held on 26 August 1971 at Hyannis to obtain information for use in preparing this report. State, town and private interests participated in the meeting. At the meeting local interests expressed a desire to develop a comprehensive plan which could involve Federal participation in the cost sharing of recommended improvements. Town officials and private property owners were unanimous in their concern with continuing erosion of beach areas. Erosion has reduced public beaches making them inadequate and unsuitable to meet the increasing demands for recreational saltwater bathing needs. Property owners have observed a change in the texture of beach material, fronting their property, toward a more rocky material in recent years. Many protective structures and natural sand dunes along the backshore have become exposed to direct contact with tidal fluctuations due to the loss of sand within the tidal zone.

Problems of erosion along the entire shoreline within the study area were presented geographically from west to east and various plans to aleviate the erosion were presented for consideration. Charts made of the entrance to Popponesset Bay in the mid 1800's indicated a natural spit joining Popponesset Beach to the mainland at Meadow Point. The 1954 hurricane

broke through the barrier beach causing the State of Massachusetts and property owners to construct groins and seawalls to protect their shoreline along Meadow Point, trapping sand which formerly nourished the shoreline further east. Some individuals were of the opinion that Popponesset Beach should be widened with groins constructed along the beach and a terminal jetty at the eastern end to stabilize the entrance to Popponesset Bay. There are erosion problems along the beach between Rushy Marsh and Bluff Point. Property owners have constructed groins at irregular intervals in an attempt at stablization. It was suggested that these groins should be raised to enlarge the town-owned beaches in this area.

Sampsons Island at one time was seperated from Dead Neck Island and the original entrance to Cotuit Harbor passed between the two islands. A coastal schooner ran aground at the entrance to this channel causing sand to eventually seal the entrance. The new channel formed west of Sampsons Island. The westerly tip of the island is building toward the northwest. This end of the island was cut back by the state in 1968 to maintain a safe channel for small craft using Cotuit Bay. When sand builds up in this area, a shoal forms at the junction of the channel and Seapuit River causing the tidal currents in the Seapuit River to increase with resulting erosion of the shoreline on both sides of the river. The ocean side of Sampsons and Dead Neck Islands have not experienced severe erosion. At a point on Dead Neck Island 300 yards west of the entrance to West Bay the 1954 Hurricane Carol broke through, creating a tidal opening 200 feet wide. The opening partially filled in under normal tidal action.

In 1958 the entrance channel to West Bay was dredged, due to shoaling about 200 yards outside the entrance and the material was used to rebuild the breach caused by the hurricane. Since that time more than half of the sand has washed away. At this time there is severe erosion between the breakthrough and the west jetty at the entrance to West Bay. The material lost from the shoreline has ended up in the outside channel entrance. The island is an Audubon Society preserve. Local interests claim that the west jetty should be rebuilt and extended to the north. Between the cast jetty at the entrance to West Bay and Dowses Beach, property owners have constructed a series of groins. Sand builds up on the west side of these groins during the summer and on the east side in the winter. Severe erosion was caused along this portion of the shoreline during the 1944 hurricane. Some properties lost up to 50 feet of land inshore of the high water line as a result of the hurricane. Those properties without seawalls are continuing to lose sand each year.

The entrance channel to East Bay was dredged in 1971 and the majority of the material was placed on Dowses Beach There has been erosion on the west end of this beach ; possibly a groin midway along the beach might slow the erosion. There is severe erosion landward of the inner end of the west jetty and the material is being deposited in the harbor entrance channel. On the east side of the entrance channel the point of Long Beach has eroded back at least 100 feet. About 20,000 cubic yards of the material dredged from the entrance channel in 1971 was placed on the beach. Local interests claimed that absence of a jetty on the east side of the entrance channel channel has allowed winds from the southwest to cause the sand to move away.

Long Beach has experienced severe erosion. The entire width of the peninsula has narrowed by 50 feet in recent years. The 1944 hurricane broke through the beach opposite the entrance to Bumps River. This breach closed naturally over a two-year period. Material eroded from Squaw Island is being deposited at Hall's Creek closing off the entrance, and restricting access to small boats.

From Squaw Island to the Hyannisport breakwater there is continuous erosion. The inner half of the breakwater at the entrance to Hyannis Harbor is in need of rebuilding. There is movement of sand from the breakwater eastward to Kalmus Park presenting a threat of closure of the outlet draining the marsh area adjacent to Keyes Memorial Beach. The erosion at Veterans Memorial Park extends northward to Snow's Creek causing the entrance to fill. Although a jetty has been built at the entrance to the creek, it has not been effective in controlling the drift of sand. Snow's Creeks' valuable conservation area is being threatened by closing of its outlet.

In summary, the problem of beach erosion caused by storm wave attack constitutes the purpose of this study and report. Local interests desire a comprehensive plan that will mitigate beach erosion and have presented several suggestions to accomplish this goal which would require the use of jetties or other littoral barriers at the entrance to inlets to impound the drifting sand and periodic nourishment of certain beach areas with sand dredged from entrance channels to the inlets.

FACTORS PERTINENT TO THE PROBLEM

GEOMORPHOLOGY As previously stated the shoreline consists mostly of glacial deposits covered with marine deposits presenting a series of sandy bay mouth bars or barrier beaches forming a generally smooth shoreline fronting tidal rivers and bays interrupted by inlets to the tidal bays.

LITTORAL MATERIALS: a. Character of littoral materials was determined from 75 surface samples taken along 13 of 31 beach profiles spaced between Squaw Island and Osterville Point. An average of six samples were taken along each of the thirteen selected profiles. Mechanical analysis of the samples indicated that nearly all of the littoral material consisted of medium to fine sand. Some coarse sand and gravel was encountered in the surf zone and shoreward of the 6 foot mean low water depth contour, while fine sand was found to be predominant between the 12 and 18 foot depths.

b. Sources-Glacial deposits constitute the principal source of supply of beach building materials. These sources have been depleted by erosion of the mantle of unconsolidated material or they are now cut off by man made structures and can therefor no longer contribute materials to the eroding areas. The minor streams emptying into Nantucket Sound, within the study area, contribute little or no beach nourishment material due to the low hydraulic gradient from the small drainage areas. However, experience with dredging operations within the inlets and bays indicate that sources of material suitable for beach nourishment exists.

LITTORAL FORCES a. Waves. The shoreline is directly exposed to waves from the Atlantic Ocean entering through the four mile wide Vineyard Sound from the southwest, the ten mile wide Nantucket Sound opening between Monomoy Point and Nantucket Island to the east and the seven mile wide Muskeget Channel between Martha's Vineyard and Nantucket Island to the south. Waves from these directions are reduced considerably in height by the limited fetch across Nantucket Sound and by the shoals within the Sound. The shoreline is sheltered from the northwest to the northeast by the mainland of Cape Cod. No wave measurements or statistical wave data are available for the immediate area. A wave rose based on synoptic weather charts for a deep water location off Nauset Beach, Orleans, Massachusetts is shown on Plate 1. It indicates that waves off Nauset Beach occur with greatest frequency from the northeast and east and that waves from the southerly directions, to which the shoreline is more directly exposed, occur with considerably less frequency primarily accompanying storms of tropical origin. Due to the sheltering effect of the offshore islands of Martha's Vineyard and Nantucket swells do not reach the south shore of Barnstable. As waves travel from deep water, they change height and direction because of refraction, shoaling and bottom friction resulting in reductions in height and shortening of the wave length and period of time between successive crests.

Waves within Nantucket Sound are generally short period waves generated by wind blowing over the limited fetches created by the offshore islands. Where wind generated waves are formed by limited fetches their height is less than ocean waves because of the restrictions of the total

amount of energy transferred from wind to water before the waves encounter the windward shoreline. The maximum height of waves breaking inside the low water line, accompanied by storm tides 3 feet in excess of the mean high water elevation is approximately 7 feet but during infrequent higher tides caused by hurricanes, larger waves can reach the shore. The above maximum wave heights apply to exposed locations only, not to shores of bays and coves.

b. Currents. Tidal currents within Nantucket Sound flood to the northeast and ebb to the southwest maximum average velocities in the entrances to Lewis Bay and Cotuit Bay are 0.9 and 0.5 knots on the flood tide and ebb at 1.3 and 0.7 knots, respectively. Between Wreck Shoal and Eldridge Shoal, located 4.5 nautical miles seaward of the entrance to West Bay, the currents are 1.7 and 1.4 knots on the flood and ebb tides, respectively.

c. Winds. Records of winds observed by the United States Weather Bureau at Nantucket, Massachusetts for a five-year period from August 1952 to July 1957 and a two-year period from August 1958 to July 1960, show that winds blow in a prevailing direction from the west about two-thirds of the time and from an easterly direction about one-third of the time. Onshore winds from the southwest quadrant have a slightly longer duration than from the northwest quadrant and double the duration of onshore winds from the southeast quadrant. A wind diagram based on the observed data is shown on Plate 1. Analysis of records, where wind speeds of 30 miles per hour or higher occur, shows that north-northeast winds are most frequent and have the longest duration. Northeast and east-northeast winds have the highest average speeds. Winds having the shortest duration are from the onshore directions of the southeast

through the southwest with those winds from the southwest quadrant having a much longer duration than from the southeast.

d. Storms. Because of the geographical orientation of the south shore of Barnstable, it is exposed to hurricanes and winter storms moving northeastward along the Atlantic seaboard. These storms cause serious problems of tidal flooding and beach erosion. Hurricanes have higher wind speeds, normally move with a faster forward speed, have a smaller area of intense winds and shorter fetch lengths than northeasters. Severe damage has been experienced from three hurricanes in the past thirty-eight years. The hurricane of September 1938 caused tidal flooding of over 14 feet above mean sea level. Flooding associated with the 1944 hurricane caused the highest flood levels in the outer islands and along the south shore of Cape Cod. The August 1954 hurricane Carol caused flood levels of one to two feet above the 1938 flood levels. Northeast coastal storms are less severe on the south side of Cape Cod. They can occur at any time of the year although more numerous in the winter months. Eighteen severe storms were recorded in the winter 1957-1958. Although most of these storms pass rapidly, some stall for several days subjecting the shore to extended damage. Strong winds of the storms often create a surge which raises the water level above the predicted average tide levels exposing to wave attack higher parts of the beach not normally vulnerable to waves. The surge is accompanied by wind generated large steep waves which carry large quantities of sand from the beaches to the nearshore bottom with each succeeding tidal cycle. Land structures, inadequately protected and located too close to the water, are then subjected to the forces of the waves and may be damaged or destroyed.

PHOTO 1. July 1971 looking west at Osterville Point (Wianno), note backshore revetment and groin structures constructed by the State to retard the erosion of the shoreline.

e. Tides. Tides are semi-diurnal. The mean ranges are 2.3 feet at Popponesset Island, 2.5 feet at Cotuit Bay entrance and 3.1 feet at Hyannisport. Spring ranges are 2.8 feet at Popponesset Island and 3.7 feet at Hyannisport. Tides 3.0 feet above mean high water are predicted to occur about once a year.

Analysis of Problem

SHORE HISTORY. a. Shoreline Changes. High water shoreline changes recorded from 1846 to 1962 indicate no dramatic changes in areas where the shoreline is not affected by tidal flow at inlets to the bays. The most pronounced changes have occurred at the entrance to Popponesset Bay, Sampsons Island and Long Beach. At Popponesset Bay between 1846 and 1941 an offshore bar steadily grew in a northerly direction to a point opposite the entrance to Rushy Marsh Pond. Subsequent storms and hurricanes eroded this bar back approximately one mile to its present position, so that the entrance to the bay is now located south of Meadow Point. Sampsons Island joined with Dead Neck and the northwesterly tip of the island has migrated toward the mainland, reducing the entrance to Cotuit Bay. Long Beach has continuously eroded since 1846 so that it is now only slightly more than one half its original width. The southwesterly side of Squaw Island eroded an average width of 250 feet between 1846 and 1938 but has since accreted approximately 100 feet in width. Inside Hyannis Harbor and along the north shore of Lewis Bay the shoreline receded an average of 150 feet between 1846 and 1940 but both areas have since become stablized and no further erosion has occurred. The remaining shoreline experienced recession of approximately one foot per year. How-

ever in recent years the majority of the exposed shorelines from Cotuit Harbor east to Lewis Bay has been influenced by construction of various types of protective structures. These protective works have, for the most part, stabilized the shoreline, and in the area between Squaw Island and the Hyannis Breakwater significant accretion has occurred. A marked degree of accretion has occurred on the west side of the jetty constructed at Dunbar Point.

b. Offshore Depth Changes. Movement of offshore depth contours were irregular and of a relatively small magnitude at the deeper depths. Changes in the 6 and 12 foot contours indicate a seaward buildup between Cotuit Bay and Wianno while off Craigville Beach eastward to Hyannis Harbor the contours, although irregular, show a balance between shoaling and deepening. Within Lewis Bay the 6 foot contour moved dramatically seaward between 1888 and 1942 forming a hook shaped shoal extending halfway across the bay from the northshore.

c. Prior Corrective Action and Existing Structures. Many protective works have been constructed throughout the study area over a progressively long period to prevent erosion of beaches and back shore sand dunes, to prevent storm damage to cottages and year-round residences, and to restore losses of beach material and to stablize inlets. Structures have consisted of sea walls, revetments or bulkheads, mostly of light construction, built to armor the shore or protect developments located in close proximity to the water. Jetties have been built to stabilize inlet entrances and to reduce the need for maintenance dredging. Historical information concerning these structures is not readily available. The location and types of structures along the exposed shoreline of the study area are listed as follows: Meadow Point to Rushy Marsh Pond outlet-protection

PHOTO 2 July 1971 Dowses Beach, looking west, note wide beach berm at this time of the year.

PHOTO 3 - Looking east July 1971 Dowses Beach, note the State jetty structure retaining the sand which would normally be deposited in the channel.

Photo 4. July 1971 looking west along Long Beach at private undeveloped section of the beach.

consists of a series of thirteen stone groins averaging 100 feet in length, backed by revetment and seawalls; Cotuit Highlands to Bluff Point, - concrete and stone seawalls, revetment and stone groins; entrance to West Bay-flanked by stone jetties, Wianno Shores to Phinneys Bay-series of stone groins, seawalls and revetment; entrance to East Bay-stablized by a stone jetty limiting the east end of Dowses Beach; at the eastern end of Long Beach-local residents have constructed massive concrete seawalls, stone revetment and a stone groin; at the west side of the entrance to Hall Creek-there is a stone jetty; the south side of Squaw Island-there is a series of thirteen stone groins of varying lengths; at the west side of Hyannis Harbor-a stone breakwater extending 4,700 which forms protection for the outer anchorage area; both sides of the entrance to a tidal inlet west of Keyes Memorial Beach kept open by two stone jetties; between Keyes Memorial Beach and Kalmus Park Beach there are five stone jetties, rip rap revetment and stone walls; at Dunbar Point there is a stone jetty 900 feet long which contains the eastern end of Kalmus Park Beach; from Harbor Bluff to Hyannis Park in Yarmouth-the shoreline is stabilized by concrete walls, stone revetment and groins fronting individual residences. Existing structures are shown on Plate 2.

d. Beach Profiles. Beach profiles were surveyed in 1972 at thirty-one selected locations between Squaw Island and Osterville Point as shown on Plates 3, 4, and 5. Plots of the profiles are shown on Plates 6 through 11. Due to a lack of comparative surveys, seasonal changes of beach profiles could not be determined. There are irregular variations of beach slopes along the shore. Heights of beach berms above the plane of mean low water, where they existed were as follows: Craigville Beach

between 6.2 and 8.5 feet; westerly third of Long Beach beyond developed area between 6.4 and 9.5; and Dowses Beach between 8.0 and 10.5. The steeper portions of the profiles seaward of the berms ,or upper portions of the beaches ,to below low water had slopes as follows: Craigville Beach ,one vertical to 8 or 15 horizontal (1/8 or 1/15); Long Beach in developed area (1/8 to 1/10); Long Beach western Portion 1/10; Dowses Beach 1/10 to 1/15; Osterville Point 1/10. Profiles generally leveled off to slopes flatter than 1/100 to 1/200 at depths of 10 to 12 feet below mean low water along Craigville Beach, depths of 3 to 10 feet along the western portion of Long Beach, 3 to 5 feet at Dowses Beach and along Osterville Point. (See Plates 3-11)

e. Shore Processes Pertinent to the Problem. The principal sources of beach materials have been the more exposed points of land within the area. During the early days sand dunes in the backshore area served as a supply of beach material. As man encroached upon the shore, developers and property owners leveled dune areas to make way for domestic improvements such as easier access to the beach. Eroded materials have moved generally eastward forming shoals or bars at the mouths of inlets. Protective structures built along the backshore in exposed areas have practically eliminated the supply of beach building materials resulting in recession of the beaches. At the entrance to Cotuit Bay the predominate direction of littoral drift is from the east toward the bay entrance. In all other locations the greatest accumlation of sand has occurred on the west side of jetties and groins showing visible evidence of predominant eastward movement. Occassional accumulations on the east side of groins indicates that during the winter storm periods the littoral drift reverses direction. The rate of loss of beach material

PHOTO 5 July 1971 - Long Beach looking east, note seaweed, indicating approximate high tide, with very limited dry beach width above high tide.

PHOTO 6. Fall 1973 Long Beach - Looking East along the beach, note the rocks, Photo 7 is a photo showing the same area in Fall 1974

PHOTO 7. Fall 1974, looking east along Long Beach. Note Photo 6 and rock exposure. This photo shows rocks now covered.

generally exceeds the rate of supply. Due to the absence of natural sources of supply and the existence of numerous groins, the quantity of littoral drift is small. Absence of swells where wave lengths range from 30 to more than 500 times the wave height precludes the possibility of return of material from offshore. Minor streams contribute little material to the beaches.

The rate of longshore transport is dependent upon the angle of wave approach and the energy emitted by the wave. Thus, high short period storm waves will generally move more material than long period low waves.

Severe storms and hurricanes often create a storm surge which raises the water level exposing higher parts of the beach to wave attack. These waves carry large quantities of sand from the beach casting it onto low lying backshore areas or moves the material into the near shore bottom. Storm surges are especially damaging if they occur concurrently with astronomical high tides.

When storm waves erode the berm and carry the sand offshore, the protective value of the beach is reduced. The width of the beach berm at the time of a storm is thus an important factor in the amount of upland damage a storm can cause. Within the study area short period storm waves have been the chief cause of littoral drift and offshore loss of beach material. Because of the location of offshore islands, swells from the open ocean ranging from 30 to more than 500 times the wave height cannot reach the beaches. These swells serve to return eroded material from offshore. Alternate erosion and accretion of beaches may be seasonal; winter storms tear the beach away and the summer swells

rebuild it. Beaches may also follow long-term cyclic patterns, eroding for several years and then rebuilding for several years.

Beach profiles taken within the study area indicate a relatively steep slope within the tidal range and a very flat horizontal slope at deeper depths. Thus coarse sand and gravel will be deposited and remain on the steeper slopes while the finer more suitable beach materials will be deposited in the offshore areas. Because of the absence of onshore movement of material by swells the finer materials cannot return to the beach under normal summertime accretion conditions.

Possible Solutions

In general, measures designed to stabilize the shore fall into two classes: structures to prevent waves from reaching erodible structures such as seawalls, bulkheads and revetments; and an artificial supply of suitable beach sand to make up for a deficiency in sand supply through natural processes. Other manmade structures, such as groins and jetties, are used to retard the longshore transport of littoral drift. These may be used in conjunction with seawalls or beachfills or both. (See Plate 12) Gently sloping beaches and beach berms are the outer line of defense to absorb most of the wave energy. When maintained to adequate dimensions, they afford protection for the backshore. Therefore, a beach is classified as a shore-protection structure.

The most feasible method of reducing erosion would be to artificially place suitable beachfill material directly on the beaches forming a desired flatter slope in the tidal zone than the present slopes or in stockpiles on the updrift side of the littoral drift to be distributed by wave action. Investigations indicate that suitable material is available offshore within a practicable distance for hydraulic dredging

PHOTO 8. July 1971, looking west along Long Beach, Mr. Goldberg's groin in the foreground. Note some difference in sand buildup at this time of the year.

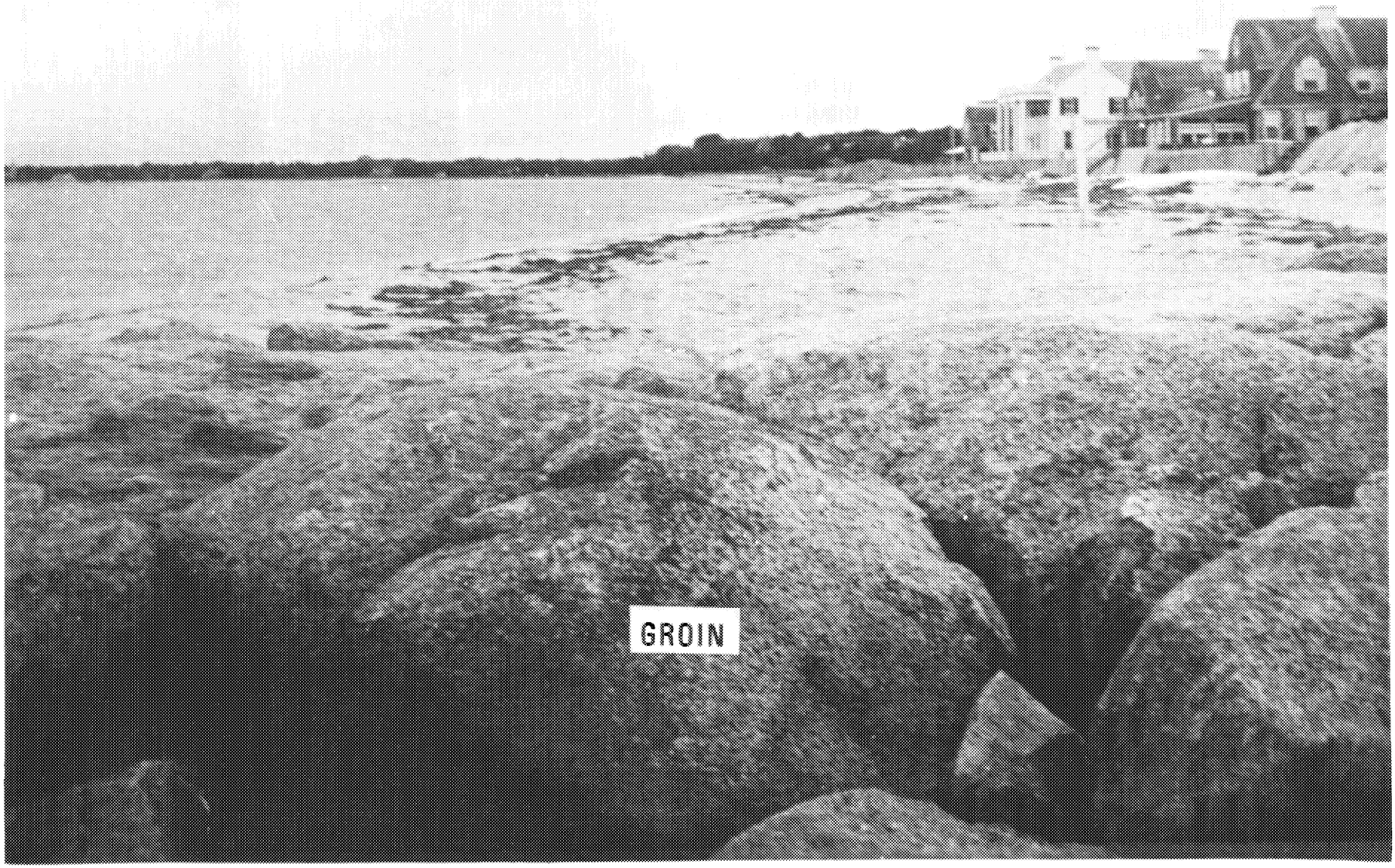


PHOTO 9. Fall 1974, looking west from Mr. Goldberg's groin, note dry beach area line, right side of photo is reduced compared to dry beach in Photo 8.

and placement on the beaches. Widening the beaches in this manner is an effective method for restoring past losses, improving beaches for recreational use and providing protection for developed areas.

Where areas are in need of restoration by artificial nourishment, they should consist of long stretches. Separate protection for short reaches within a larger zone of eroding shore, is difficult and costly to place and maintain. Such protection often fails as the flanks of the fill area are exposed and the unprotected shores continue to recede. Partial or inadequate protection by sand fill may even result in acceleration of erosion on adjacent shores. Coordinated action by all property owners within the area of erosion should be accomplished under a comprehensive plan which would consider protective means covering the full length of the shore compartment subject to erosion.

Sand fill generally provides the needed protection but in order to hold the material it may be necessary to provide groins which would interrupt the long shore sand movement thereby accumulating sand along the shore. This method of trapping the sand by a groin is done at the expense of the adjacent downdrift shore unless the groin system is artificially filled with sand to its entrapment capacity from other sources. To reduce potential erosion to property downdrift of a groin, some limitation must be imposed on the amount of sand permitted to be impounded on the updrift side.

Jetties are employed at inlet entrances to eliminate or reduce shoaling in the entrance for navigation purposes. When sand is transported along the shore by waves and currents, it flows inward on the flood tide to form an inner bar, and outward on the ebb tide to form an off-

shore bar. Both formations interfere with navigation and must be controlled to maintain an adequate navigation channel. The jetty acts in a similar manner to groins and to be effective it must be high enough and long enough to completely obstruct sand movement along shore. Thus while a jetty may be effective in providing navigation passage it will also starve the downdrift shore causing erosion. To eliminate undesirable downdrift erosion, the sand impounded by the jetty may be hydraulically pumped to the eroding beach, providing an intermittent flow of sand to nourish the downdrift beach.

Numerous groins and jetties have been constructed along the shore and have proven to be effective in reducing losses. Loss of backshore land has been reduced except under severe storm and hurricane conditions, by armoring the shore with sea walls, revetments and bulkheads. Landward movement of material under storm conditions can be prevented or reduced by raising roads where they border the backshore.

An offshore breakwater could be an applicable method of beach protection if it is aesthetically acceptable. Breakwaters are located and aligned a littoral reservoir and are only effective where there is considerable along shore movement of sand. Littoral drift is deposited in the lee of the breakwater. As sand is deposited, a seaward projection of the shore is formed in the still water behind the breakwater. This projecting shore in turn acts as a groin, which causes the updrift shoreline to advance. As the projection enlarges and the zone of longshore transport moves closer to the breakwater, it becomes increasingly effective as a barrier to sand movement. Where a breakwater is sufficiently long relative to its distance from the shore the sand depositing action may form a tombolo with the breakwater at its apex. A series of short breakwaters would have the same general

effect as a long single unit. However offshore breakwaters are extremely expensive to construct when compared to other methods of protection.

DESIGN CRITERIA.- Normally protective measures should be designed to provide protection for storm conditions which may occur on frequency of once per year. They are not intended to provide complete protection in the event of hurricanes or great storms of infrequent occurrence, although even under these conditions most structures will afford some protection at lower stages of the tide.

a. Design Tide. The design tide is the highest tide which could occur on an average of once a year. The elevation of this design tide is 3.9 feet above the plane of mean low water.

b. Design Wave. The height of the design wave was determined from the relationship d/H=1.28 where d is the depth of breaking and H is the height of wave at breaking. The depth of breaking is the still-water depth at the point where the wave breaks.

c. Sizes and Slopes of Armor Stone in Structures. Sizes and slopes of armor stones for groins, jetties and stone revetments are computed using the United States Army Coastal Engineering Research Center formulas described in the publication, Shore Protection Manual, published in 3 volumes.

d. Groins. Generally, the horizontal shore section of groins should have a top elevation not lower than the general height of existing beach berms or approximately 8 feet above mean low water and a length equal to the berm of the anticipated beach. The intermediate sloped section should be not steeper than the slope of the existing shore adjacent to the section. The top elevation of the outer section should not be lower than one foot above the plane of mean low water. Groins should be sand tight and firmly anchored at thier inshore end to prevent flanking. Groin lengths are generally determined by the toe of the anticipated beach or sand fill section.

e. Jetties. The above criteria on height and length of a groin applies except that in stone construction the minimum height of the outer section should not be lower than 5 feet above the plane of mean low water. This height is increased wherever necessary to permit use of proper sized armor stone which will not be displaced by design wave action. Blankets of spalls or crushed stone are used under stone structures to minimize settlement and scour.

f. Sand Fill. The berm elevation of proposed beach fills is based on those at existing beaches in the study area. The minimum width of fill above mean high water is based on widths found to afford protection in the area. Estimated volumes of fill are based on slopes similar to existing slopes but fill can be placed initially to a steeper slope and permitted to take a more natural slope from wave action. Based on these criteria the beach width between backshore structures or natural dunes and the proposed high water shoreline should be approximately 125 feet. the berm elevations should be about 7.0 feet above mean low water and the fill slopes should vary from 1 on 10 to 1 on 30 in accordance with existing slopes. Suitable sand for beach fills should have size and gradation characteristics similar to those of the existing beach materials. For the purpose of specific design details investigation of materials on the beach and in proposed borrow areas should be supplemented when plans and specifications are prepared for any proposed project.

PLANS OF PROTECTION

GENERAL Plans of protection have been considered for all known beach erosion control problems throughout the study area. Detailed plans have been developed for all specific problem areas where there is a present need for protection or improvement and typical plans or methods of protection have been indicated for use in areas where it appeared

that a need for protection might develop. Descriptions, problems and plans of protection for shore areas, divided in accordance with the physical character of shore features or the limits of public ownership, are contained in the following paragraphs. The location of these shore areas are shown on Plate No. 2 .

MEADOW POINT TO BLUFF POINT Meadow Point is located at the western limit of the study area. The shore has a length of approximately 2.25 miles not including the sand spit located adjacent to Rushy Marsh Pond. Within this area is a very small public beach about 100 feet long located at the so called "Loop Area" at Cotuit Highlands. The remainder of the shore is privately owned and occupied by cottages and year-round residences. The shore is composed of boulders, cobbles, gravel and sand. A low sand spit trails southward offshore at Rushy Marsh Pond. This sand spit is the remains of an offshore barrier beach which formerly connected to an offshore barrier beach fronting Popponesset Bay. The barrier beach was destroyed by a hurricane in 1954 and the present Popponesset Beach was formed. Popponesset Bay inlet is presently located at the northerly tip of the barrier beach between Thatch Island and Meadow Point. In 1958 stone groins and a seawall were constructed along Meadow Point by the Commonwealth of Massachusetts to rebuild the shoreline that was damaged by Hurricane Carol in 1954. Total cost was $138,000. The shoreline northeast of Rushy Marsh Pond is protected by seawalls, revetment and stone groins facing privately owned property. No additional work is needed along this stretch of shoreline except for maintenance of individual groins where stones have been displaced.

In general, maintenance of existing walls and raising of riprap revetment to prevent overtopping should provide suitable protection in this area. Since there are no longer any sources supplying the small beaches between the groins improvement of the public beach and privately owned beaches can only be effected by artificial nourishment. Suitable beach fill material exists offshore in the vicinity of the sand spit opposite Rushy Marsh Pond.

COTUIT BAY TO OSTERVILLE POINT The portion of shoreline extending from Bluff Point to Osterville Point contains the undeveloped Sampsons Island and Dead Neck Island which were joined together when the former entrance between the islands was filled in by drifting sand following the grounding and loss of a coastal schooner. The present entrance to Cotuit Bay is located between Bluff Point and Sampsons Island. Littoral drift along the southwest side of Sampsons Island causes a sand pit to form on the northwest tip of the island which effectively scours the entrance channel to depths of more than six feet. However, growth of this sand spit has periodically been cut back by the State in an attempt to improve navigation. North of Sampsons Island the bay widens to 2,000 feet between Bluff Point and Osterville. This outer portion of the Bay is shoal with depths ranging from one to seven feet below mean low water. The inner portion of Cotuit Bay has adequate depths to 14 feet. Owners of recreational craft using the Bay have experienced considerable difficulty in navigating the outer portion of the Bay when using either the inlet or the longer route through Seapuit River leading into West Bay.

The area, located at the entrance to Cotuit Harbor, is not primarily a beach erosion problem but rather the need is to stabilize the entrance and improve navigation. A stone jetty 700 feet long should be constructed

on the west side of Sampsons Island to trap sand moving along shore toward the entrance. In conjunction with the jetty maintenance of a channel approximately 100 feet wide and 8 feet deep at mean low water should be considered between Bluff Point and Osterville. Some of the dredged material should be placed between the existing groins at Cotuit Highlands to nourish the small pocket beaches. The remainder should be placed along the north shore of Sampsons Island to strengthen the barrier beach against possible breaching by hurricanes or other severe storms. (See Plate 2)

Oyster Harbor on the south side of Dead Neck Island has experienced only minor amounts of erosion along the westerly two-thirds of the beach. At a point 300 yards west of the entrance to West Bay, Hurricane Carol broke through forming a shallow opening 200 feet wide. This opening closed naturally over the years. This area was further re-enforced against future damage by disposal of dredged material when the State dredged the entrance to West Bay in 1968. This portion of Oyster Harbor Beach is continuing to erode at a rate of 15 feet per year. Loss of the narrow eastern portion of the barrier beach could result in flanking of the stone jetty at the west side of the entrance to West Bay and exposure of valuable Oyster Harbor property on the north side of Seapuit River. Dredged material from maintenance of the West Bay entrance channel should be placed on the easterly 2,000 feet of Oyster Harbor Beach, preferably stockpiled at the western end of the area in order to prevent too rapid a build up of sand at the west jetty. Some of the sand from the entrance channel should also be placed on the shore between the east jetty and a point opposite Eel River to furnish protection in this area and a source of supply for the small pocket beaches further east toward Osterville Point. This beach is used for bathing by area ressidents. Existing seawalls and revetment, if maintained, should provide adequate protection to the land behind the beach.

The portion of the shoreline extending 3,000 feet eastward from the vicinity of Eel River has experienced only minor erosion since 1846. No harmful effects are known to have resulted from this recession. The highly developed shoreline along Wianno Beach has been protected by seawalls, revetment and stone groins as the area was developed resulting in elimination of a source of material for nourishment of Dowses Beach. The lack of change in the position of the high water line shown on the shoreline change maps indicates that any loss of beach material must be at a very slow rate. The prevention of such losses would be difficult and costly. There are no natural sources of supply contributing any appreciable amount of beach building which can be impounded by the existing groins. The small amount of materila needed for beach maintenance in the vicinity of Osterville Point would make it impractical to hydraulically dredge the materila from offshore. A more practical method of providing needed maintenance consists of periodically hauling and dumping small quantities of suitable sand at some location along the shore where wave action would transport the material throughout the area. The need for preventing sand losses or reducing seasonal variations is considered insufficient to warrant development of detailed plans.

DOWSES BEACH - The Town of Barnstable owns approximately 1,200 feet of beach at the west side of the entrance to East Bay. The Commonwealth of Massachusetts has constructed a 400-foot long stone jetty at the eastern limit of the beach to provide a stable channel entrance to East Bay. There is a bathhouse with sanitary facilities located on a small knoll at the west end of the beach and a paved parking area for 200 cars behind the beach. The dry beach width available for bathing averages 200 feet. Approximately 30,000 cubic yards of sand was

added to the beach when the entrance channel to East Bay was dredged in 1971. If additional protection to the ocean side is desired, it can be effected by direct placement of sand fill to provide a wider beach. The use of a stockpile at the west end would be effective. The west jetty is presently filled to its impoundment capacity with consequent movement of sand around the jetty into the harbor entrance. Prevention of harbor shoaling would require extension of the jetty. Eastward drifting could be reduced by construction of a groin at the west limit of the beach to hold a beach of the desired width. This would eliminate the need for further extension of the jetty. The backshore of the beach facing on East Bay is eroding and moving eastward into the inside channel. This erosion is probably caused by the ebb tide currents from Centerville River moving in a counter-clockwise direction through East Bay. To further stabilize the shoreline and reduce the need for maintenance dredging, riprap protection should be placed on the banks for a distance of 600 feet from the inner end of the jetty toward the bay side and extended an additional 200 feet around the inner point of the beach. (See Plate 2).

LONG BEACH- This barrier beach extends eastward from the entrance to East Bay for a distance of 7,000 feet. The westerly two-thirds of the beach is undeveloped, privately owned having a present average width of 300 feet. The easterly third is occupied by residences. These cottages and year-round homes built on the crests of former sand dunes are fronted by concrete walls and stone revetment. There is one stone groin extending 50 feet seaward of a riprap embankment built by a property owner.

The beach is composed of sand varying from fine to coarse with small amounts of gravel within the surf zone. The width above high water

varies considerably ranging from 10 to 70 feet. About 4500 feet of the westerly end contains low level sand dunes covered with grass and shrubs. There is some evidence of deterioration from pedestrian travel over the dunes from points along the Centerville River where access to the foreshore of the barrier beach has been made by owners of small recreational boats. The extreme westerly end of the beach, adjacent to East Bay, was used as a disposal site for approximately 10,000 cubic yards of sand from the dredging of East Bay by the Commonwealth of Massachusetts in 1971 in conjunction with the widening of Dowses Beach. The deposited sand buried cobbles which extend along the westerly shore in the tidal zone for a distance of 300 yards. Deposition of these cobbles shows evidence of converging storm driven wave energy which appears to have moved the cobbles into the surf zone from shallow offshore depths. The jetty at the entrance to East Bay extends too far seaward to permit nourishment of Long Beach with sand from Dowses Beach. Nearly all of the sand deposited in 1971 has drifted eastward along Long Beach or has moved offshore. Comparative highwater shorelines indicate that Long Beach was nearly twice as wide as its present width in 1846 which indicates that Long Beach was eroding prior to jetty construction at East Bay.

Removing the outer end of the jetty to allow sand to by-pass would result in decreasing the width of Dowses Beach causing overcrowded conditions during peak use days in the summer. The material would drift into the entrance to East Bay. Under adverse storm conditions, waves would move the sand further into the bay where it would be lost for beach nourishment. The present shoal conditions within the bay is causing navigation difficulties for recreational craft. Some sand

would reach Long Beach under favorable conditions but would be insufficient to reduce the present rate of recession to any noticable degree.

A stone groin was constructed on Long Beach by a local resident, in 1970, in an attempt to reduce erosion in front of his property by gaining additional beach width. Immediately following construction of the groin the beach to the eastward side showed an acceleration in erosion due to the interruption of littoral drift. This situation caused property owners to construct massive riprap revetment on the face of sand dunes along the backshore to protect their property. The property owner who constructed the groin subsequently replaced a wooden bulkhead fronting his property with stone riprap to provide a more substantial structure. He then placed about 1,800 cubic yards of sand on both sides of the groin building the dry beach area seaward for a distance of 20 feet. The eastward drift of sand has now filled the west side of the groin and material is moving past the groin to nourish the eroded area which resulted from its construction. The beach on the downdrift side of the groin has widened noticably indicating that littoral movement has been resumed.

To reduce erosion of Long Beach and to improve navigation access to East Bay,a stone jetty, 500 ft. long, should be constructed on the westerly end of Long Beach, parallel to the west jetty. Riprap revetment should be extended from the inshore end of the jetty along the westerly tip of Long Beach into East Bay, a distance of about 600 ft. The jetty would serve to deflect longshore currents away from the western end of Long Beach resulting in a reduction of sand loss. In conjunction with the jetty construction, sand fill should be stockpiled on the beach eastward of the jetty for

distribution by wave action and currents further east along approx. 4,000 ft. of beach. There are two small coves or indentations on the Centerville River side of Long Beach which should be filled to the level of the surrounding beach berm or dunes, to reduce the possibility of breakthrough in these relatively narrow portions during severe storm conditions. In the event that sand losses along shore from the stockpile are excessive further retention could be obtained by construction of a series of three or more groins along the central portion of the beach opposite the mouth of the Bumps River spaced approximately 500 feet apart. Landfill for placement on the beach could be obtained from dredging the entrance channel to East Bay or from suitable offshore shoal areas opposite Osterville Point. (See Plate 2).

CRAIGVILLE BEACH - This publically owned sector of the shore extends for 1240 feet east of Long Beach. The beach averages 170 feet in width above mean high water. There is a large parking area for 400 cars, a bathhouse and sanitary facilities. The extension of the beach both to the west and east contains a private beach association. There are extensive sand dunes along the backshore continuing for most of the shorefront to Hyannis Point. Development landward of the entire shorefront consists of residences, summer hotels and inns.

Craigville Beach is composed of sand varying from fine to coarse with small amounts of gravel. Comparative shoreline locations between 1846 and 1962 indicate that the shore has shown little change throughout the period. Offshore depth contours indicate that there is little sand movement along the shore with no predominant direction to currents. Erosion and accretion is attributed to on and offshore movement of sand by seasonal changes in wave action. Because of a lack of along-

PHOTO 10. July 1971 Craigville Beach looking east, note wide beach bathing area at about high tide.

PHOTO 11. July 1971 Keyes Memorial Park Beach looking east, note wide beach area and dunes along the backshore.

shore movement of sand, groins would not accomplish retention of sand in this area.

Additional recreational beach area can be provided if needed for public recreational use by placement of sand fill. This widening would provide protection for the backshore in addition to recreational area. Maintenance of the existing beach by replacement of sand losses, when needed, is a practicable method of protection and improvement.

SQUAW ISLAND TO HYANNIS HARBOR BREAKWATER - This shoreline extends approximately 7,000 feet from Halls Creek to the breakwater. The shore is privately owned. Development consists of summer homes and residences concentrated on Squaw Island and the eastern portion of Sunset Hill. The westerly 2,500 feet of the shoreline at Squaw Island consists of an undeveloped narrow sand beach fronting marshland. Along the south side of the island and the causeway leading to the mainland some riprap revetment and numerous stone groins have been constructed. The beaches consist mostly of sand varying from fine to coarse and some gravel. There are grassed sand dunes in the backshore along the south side of the island. Shoreline changes from 1846 through 1941, indicate that the westerly side of Squaw Island receded from 300 to 400 feet in width and from 1941 to 1961 accreted on an average of 75 feet. Since that time there has been a minor amount of erosion with the material moving northwest blocking the entrance to Halls Creek. Although the creek is not used for recreational boating activity the sand does interfere with drainage of the tidal marsh behind the beach. Unless the present entrance is kept open tidal differentials under severe storm conditions could result in a breakthrough on the south side of the island causing residents to be temporarily isolated from the mainland.

To stabilize the entrance to Halls Creek and reduce erosion of the barrier beach fronting the marsh, a small jetty, 500 ft. long, should be placed at the southeast side of the entrance parallel to the existing north entrance. (See Plate 2). Maintenance of existing structures along the south side of the island should provide adequate protection for the shore, residental development and the causeway under ordinary condition, but damages will occur to the access road during exceptionally severe storms. In 1936 the Commonwealth of Massachusetts completed a breakwater begun in 1912, extending southeastward from the Hyannisport shore to the west end of the Federal breakwater, a distance of 2,100 feet. The breakwater has deteriorated and is in need of repair. Storm waves pass through several breaks in the structure causing hazards to recreational boats moored in the 35 acre, 15-ft. deep anchorage. The State should repair the breakwater under its maintenance program.

HYANNIS OUTER HARBOR - This portion of the shoreline extends from the inshore end of the Hyannis Breakwater to Dunbar Point a distance of 8,000 feet. Within this area are two public beaches. The remaining shoreline is occupied by private residences, fronted sand dunes and stone groins. The westerly public beach is Keyes Memorial Beach located at the foot of Sea Street. This town owned beach is about 1,100 feet in length. It contains a parking area for about 150 cars and has a bathhouse with sanitary facilities. There is a stone groin at the west end of the beach which serves to hold sand from blocking a tidal inlet which drains the area north of Ocean Avenue. The easterly end of the beach is bounded by the remains of the Old Colony Newport Railroad wharf. The public beach averages about 100 feet in width above mean high water fronting natural sand dunes. The beach maintains itself

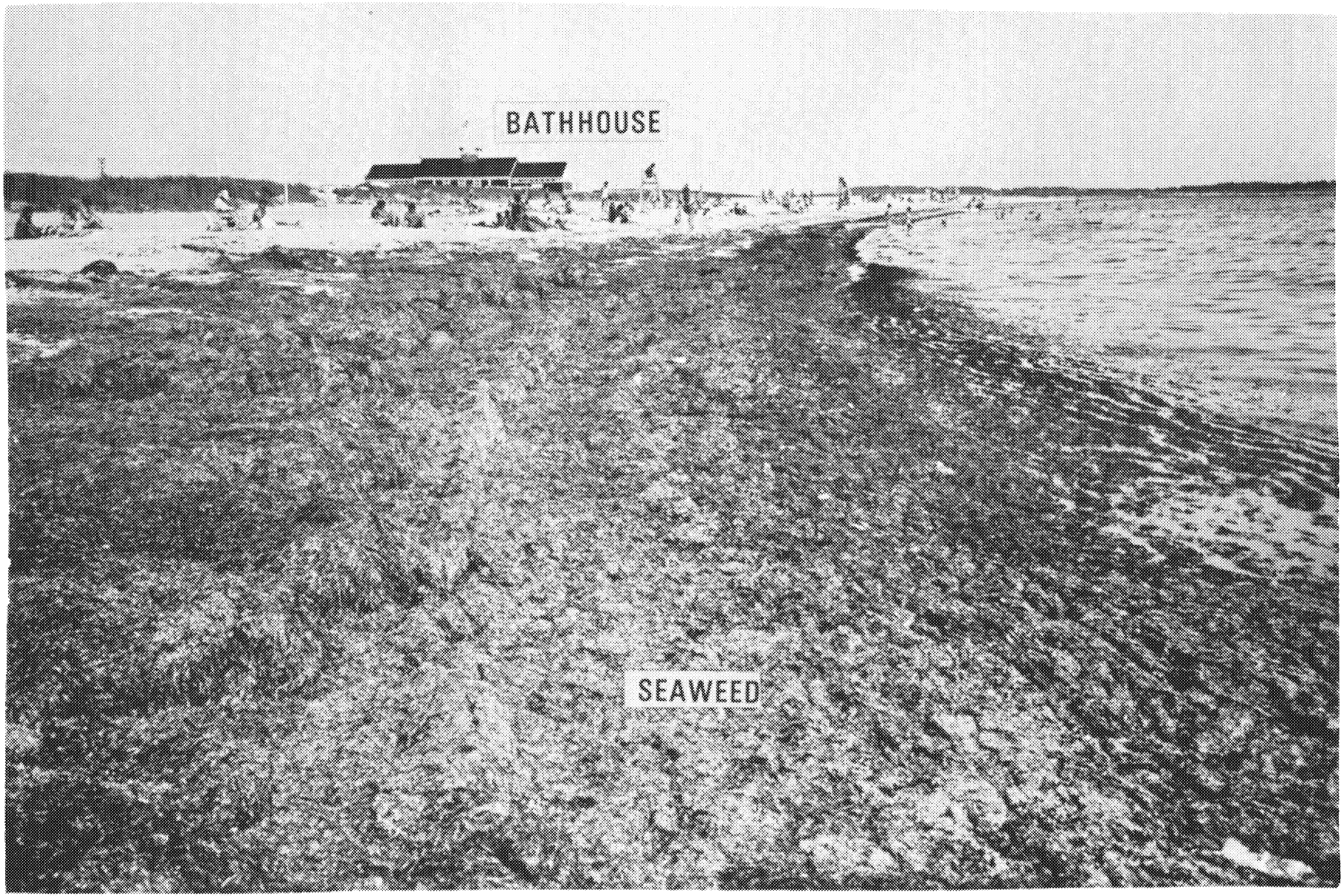


PHOTO 12. July 1971. Kalmus Park Beach looking east, note seaweed which is a problem along this section of the beach

PHOTO 13 - July 1971 Kalmus Park Beach, looking east, note bathhouse in Photo 12, in this photo bathhouse is to the right of flag. The sand dune in the background separates this beach and the beach shown in Photo 12.

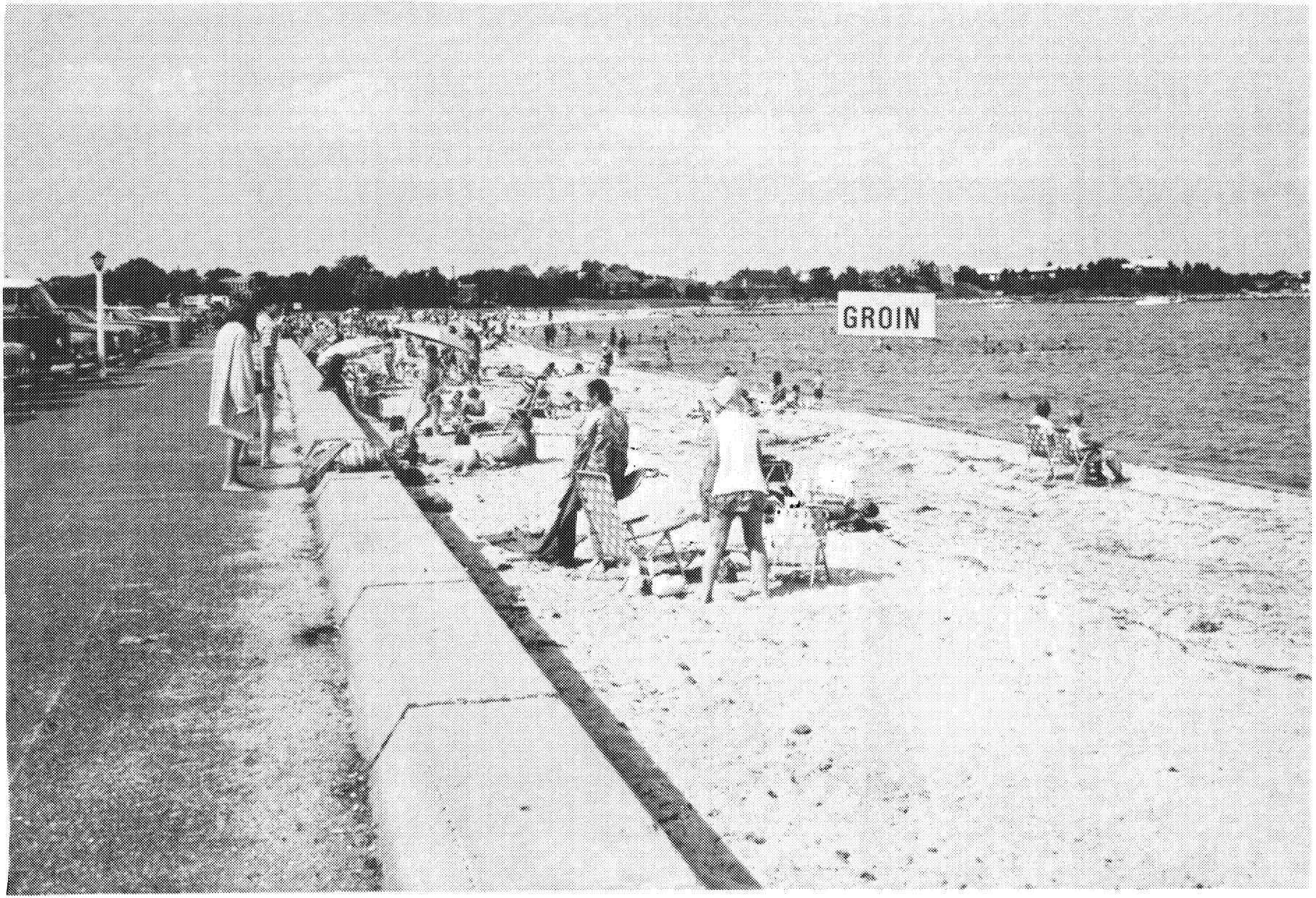


PHOTO 14. July 1971 looking north at Veterans Memorial Park Beach. This area provides picnicking, as well as parking and swimming.

by eroding the dunes during periods of extreme high water. The surf zone area is gravelly, the finer sand having moved offshore into the flatter slopes below low water. Currents and wave refractions within the harbor, have created a sand bar about 1,000 feet long located 1,500 feet offshore oriented perpendicular to the shoreline. Depths over this bar average 4 feet. No plans for improvement of this beach have been considered since the public beach is adequate for present day use.

KALMUS PARK - A town owned beach, extends about 3,000 ft. west from the jetty at Dunbar Point. About 2,500 additional feet of this park fronts on Lewis Bay. There is a centrally located bathhouse with sanitary facilities and parking lot for 400 cars. The beach fronting dunes on the harbor side is about 120 ft. wide to the east of the jetty and on Lewis Bay the dry width of beach in front of the dunes ranges from 20 to 40 feet in width. The 1,000 foot long jetty extending south from the east end of Kalmus Park Beach was constructed by the Commonwealth of Massachusetts in 1962. The Federal navigation channel leading from Nantucket Sount into Hyannis Inner Harbor was dredged in 1959. The material taken from the channel seaward of Dunbar Point was placed on the Sound side of Kalmus Park Beach for distance of 2,600 feet west of the jetty. The material upstream of Dunbar Point was used as land fill in the park between Ocean Street and Lewis Bay. The beach is adequate for present use and does not experience serious erosion to warrant additional protection at this time.

VETERANS MEMORIAL PARK - This town owned beach is located on the western shore of Lewis Bay, extending along 1,000 feet of the shorefront. The beach tapers from about 150 feet in width, above the mean high water line, at a groin at the northern extremity to 40 feet at the southern extremity.

The backshore area contains a small parking lot for about 300 cars. The park includes a bathhouse, restrooms, and picnic tables. The Hyannis Yacht Club is located adjacent to the southern end of the park. There is a boat anchorage located directly offshore within 500 to 800 feet of the beach. Due to the close proximity of the yacht club anchorage, additional widening of the existing beach should not be done to provide additional space. Sand placed on the beach could conceivably move offshore causing shoaling problems for the anchorage and yacht club docking facilities.

SUMMARY OF COST ANALYSIS FOR PLANS OF IMPROVEMENT CONSIDERED Detailed descriptions and estimates of costs for considered plans to reduce beach erosion problems are included in Appendix A. First costs for construction have been estimated for all projects for which detailed plans have been developed. Estimates of cost are based on price levels prevailing during July 1976. Detailed plans have been developed for the locations tabulated below:

Location	Shore Ownership	Work Items	Total Cost
Sampsons Island	Private	Jetty	$ 398,000
Oyster Harbors Beach	Private	Beach fill	450,000
Bowses Beach	Town	Revetment	285,000
Long Beach	Private	Jetty, Revetment and Beach fill	1,574,000
Squaw Island	Private	Jetty and Beach fill	228,000

ANNUAL CHARGES - All estimated annual charges have been computed as non-Federal annual charges. An interest rate of 6 3/8 % has been used. A useful life of 50 years has been assumed in determining

amortization charges. Maintenance estimates for beach fill are generally based on the maximum rates of loss determined from past shore recession. It is assumed that jetty construction will reduce the rate of loss of beach fill by 50 percent under normal storm conditions. Estimated annual costs are listed as follows:

Location	Interest	Amortization	Maintenance	Total Annual Cost
Sampsons Island	$25,400	$ 1,200	$ 3,500	$ 30,100
Oyster Harbor Beach	28,700'	1,400	44,100	74,200
Dowses Beach	18,200	900	2,200	21,300
Long Beach	100,300	4,800	128,400	233,100
Squaw Island	14,500	700	1,800	17,000

Benefits

Benefits have not been evaluated since economic justification is not of a type to make the projects eligible for Federal aid under existing Federal policy. All of the protection plans with the exception of the plan at Dowses Beach, are for private property and the benefits to be derived are wholly private. The project at Dowses Beach would not affect present or future recreational use of the beach but would only serve to prevent losses of the backshore area facing East Bay and reduce maintenance of the entrance channel. The other four public beaches have sufficient area to accommodate present or prospective beach use. Any widening of these beaches beyond their present width would require additional parking space for prospective beach users. There is no indication that sufficient land would be made available to provide additional parking spaces. Since the public beaches do not show signs of extensive erosion, no plans for restoration have been prepared or evaluated under this study.

Apportionment of Cost

Under existing beach erosion control laws, Congress has authorized Federal participation in the cost of restoring and protecting the shores of the United States, its territories and possessions. The intent of this legislation is to prevent or control shore erosion caused by wind and tidal generated waves breaking along the costs and shores. Beach erosion control legislation does not authorize correction of erosion at upstream locations caused by stream-flows. Federal participation in construction cost is limited to restoration of damaged beaches rather than to create new land by improvement. Accordingly, Federal participation is limited to restoration of the historic shoreline. Any additional extension of the shoreline seaward or creation of new beach areas would be entirely at non-Federal expense.

Federal participation is based on the shore ownership, and use. If there is no public use or benefit, Federal funds can not be used. The first costs allocated to restoration of or protection to Federal property are borne fully by the Federal Government. Federal cost sharing is at least 50 percent of the first cost of protection for shores owned by non-Federal public agencies, exclusive of land costs. Protection of certain shores not publically owned may be eligible for Federal cost sharing up to 50 percent providing it can be shown that there is significant public benefits arising from public use or from direct protection of nearby public facilities.

Section 103 of the 1962 River and Harbor Act provides Federal cost sharing up to 70 percent of the total construction cost for protection of publically owned shore park and conservation areas, provided that:

(a) The land must be publically owned.

(b) The park must include a zone extending landward from MLW line which excludes all permanent human habitation, excluding summer residences, but does preclude residences of park personnel or administrative buildings.

(c) The park must include a beach suitable for recreational use including swimming and similar water contact use.

(d) The park must provide for preservation, conservation, and development of the natural resources of the environment.

(e) The park or conservation area must extend landward a sufficient distance to include protective dunes, bluffs or other natural features which will absorb and dissipate wave energy and flooding effects of storm tides. The purpose of this requirement is to provide a protective buffer zone which would prevent damage of upland property and development.

(f) Full park facilities must be provided for appropriate public use.

Private shores owned by beach clubs and hotels are not eligible for Federal aid even though the clubs or hotels may indicate that membership or guest privileges are open to all on equal terms. Usually these establishments are operated for private profit or to restrict beach use. They exclude all members of the general public except for membership or paying guests. It is considered that their facilities, including parking facilities therefore, are not open to the general public. However, protection of such private shores must sometimes be included when determined essential to a complete overall restoration project. The term "public use" means recreational use by all on equal terms and open to all regardless of origin or home area. Prohibited is any device

for limitation of use to specific segments of population, such as local residents, or similar restrictions on outside visitors, directly or indirectly. This definition allows a reasonable beach entrance fee, uniformly applied to all, for payment of local project costs. Lack of sufficient parking facilities for the general public (including non-resident users) located reasonably near and accessible to the project beaches would constitute a defacto restriction on public access and use of such beaches, thereby, precluding eligibility for Federal assistance.

Within the study area the benefits which could be evaluated for protection of public shores are insufficient for economic justification. Protection of private shores would not result in significant public benefits based on the above criteria. Therefore, all estimated costs are apportioned as non-Federal costs.

Coordination With Other Agencies

Coordination has been maintained with the Massachusetts Department of Public Works and with officials of the Town of Barnstable. They furnished information and data used in the conduct of this study. The plans of protection were discussed with both during the progress of the study and their comments were requested for inclusion in this report. In addition, personal contact has been made with shore residents to ascertain data concerning their problems.

COMMENTS BY LOCAL INTERESTS - The results of this study have been discussed with the Division of Waterways of the Massachusetts Department of Environmental Quality Engineering and with officials of the Town of Barnstable. (See Appendix B).

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The Division Engineer concludes that the following are practicable plans for protection and restoration of shore areas which merit consideration, all are shown on Plates 2 and 12.

(a) Sampsons Island - Construct a stone jetty 700 feet long at the western end of the island.

(b) Oyster Harbor Beach - Widen 2,000 feet of beach at the eastern end of Dead Neck Island by direct placement of sand fill.

(c) Dowses Beach - Place riprap revetment along the eastern and northern tip of the beach facing East Bay for a distance of 800 feet.

(d) Long Beach - Construct a stone jetty 500 feet long at the western end of the island. Place riprap revetment from the inner end of the jetty along approximately 600 feet of the western end of the beach. Widen 4,000 feet of the beach by direct placement of sand fill including sand fill in two seperate areas of the backshore fronting on Centerville River.

(e) Squaw Island - Construct a 500 foot long jetty adjacent to the east entrance to Hall Creek.

The remaining shore areas are in general suitably protected against erosion and shore recession by existing protective works. Maintenance of existing structures or construction of additional similar structures is all that is needed at the present time. If it is desired or becomes necessary in the future, the existing beaches can be improved,maintained or restored by placement of sand fill directly on the beaches or in stockpiles to be distributed by wave action.

The western two-thirds of Long Beach is considered unsuitable for residential development due to its low elevation and vulnerability to overtopping and damages during severe storms or hurricanes.

Complete protection of low shore areas by high seawalls or other barriers to prevent overtopping and consequent damages during severe storms or hurricanes is not warranted by the limited developments which would benefit.

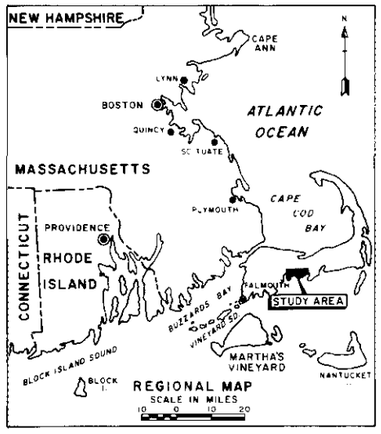
Due to the adequacy of public beach areas for present recreational use or the private ownership and consequent private benefits to be derived from protecting private property, the public interest under existing policies is insufficient to warrant Federal participation in the cost of the projects considered.

Recommendations

It is recommended that no project be adopted by the United States at this time for the protection or restoration of the south shore of Barnstable, Massachusetts. It is further recommended that protective measures which may be undertaken by local interests based upon their determination of economic and environmental justification be accomplished in accordance with plans and methods considered in this report.

CORPS OF ENGINEERS

U. S. ARMY



COMPOSED OF DATA OBTAINED BY HINDCAST OF 3 YEARS OF WIND RECORDS (1948-1950) SHOWING PERCENT OF TIME WAVES OF DIFFERENT HEIGHT OCCUR FROM EACH DIRECTION. FROM BEACH EROSION BOARD TECH. MEMO. NO. 55.

WAVE ROSE

OFF NAUSET BEACH, CAPE COD, MASS.

(LAT. 41° 50' N, LONG. 69° 30' W)

*DURATION FOR EACH RANGE OF WIND SPEEDS IS MEASURED OUTWARD FROM TOP OF UNDERLYING BAR GRAPH.

NOTE:

PERCENT DURATION PER DEGREE IS THE AVERAGE PERCENT DURATION OBSERVED FOR EACH 16 POINTS OF THE COMPASS DIVIDED BY 22 1/2 DEGREES.

WIND ROSE

MEMORIAL AIRPORT, NANTUCKET, MASS.

AUGUST 1952-JULY 1957 AUGUST 1958-JULY 1960

AUGUST 1961-JULY 1962

8 YEAR RECORD

BEACH EROSION CONTROL STUDY OF SOUTH SHORE OF BARNSTABLE, MASS.

LOCATION MAP

NEW ENGLAND DIVISION - CORPS OF ENGINEERS

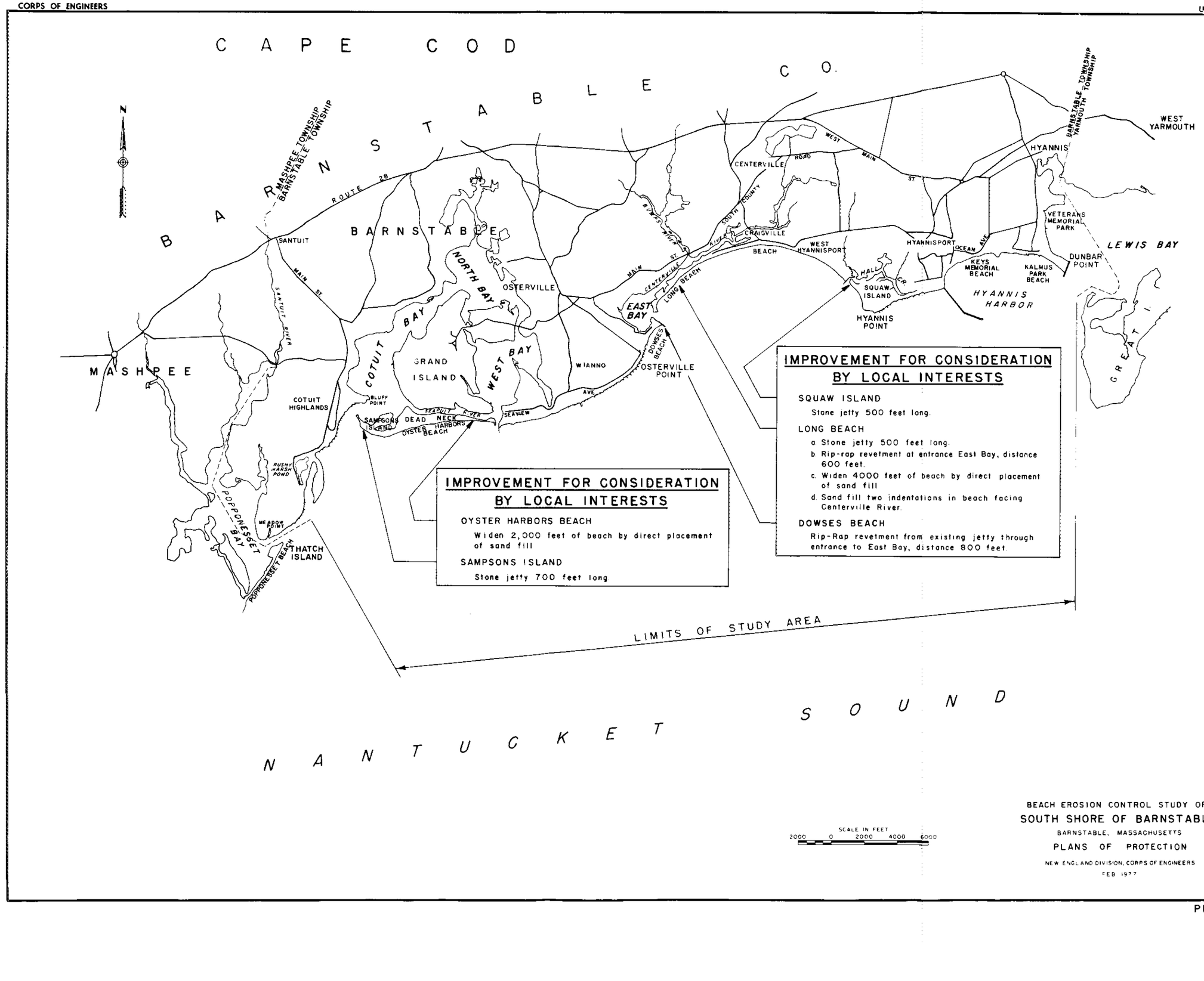
FEB. 1977

TRACED FROM N.O.S. CHARTS 13237 & 13218

PLATE 1

CORPS OF ENGINEERS

U. S. ARMY



IMPROVEMENT FOR CONSIDERATION BY LOCAL INTERESTS

SQUAW ISLAND

Stone jetty 500 feet long.

LONG BEACH

a. Stone jetty 500 feet long.
b. Rip-rap revetment at entrance East Bay, distance 600 feet.
c. Widen 4000 feet of beach by direct placement of sand fill
d. Sand fill two indentations in beach facing Centerville River.

DOWSES BEACH

Rip-Rap revetment from existing jetty through entrance to East Bay, distance 800 feet.

IMPROVEMENT FOR CONSIDERATION BY LOCAL INTERESTS

OYSTER HARBORS BEACH

Widen 2,000 feet of beach by direct placement of sand fill

SAMPSONS ISLAND

Stone jetty 700 feet long

SCALE IN FEET
2000 0 2000 4000 6000

BEACH EROSION CONTROL STUDY OF
SOUTH SHORE OF BARNSTABLE
BARNSTABLE, MASSACHUSETTS
PLANS OF PROTECTION
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
FEB 1977

PLATE 2

WEST HYANNISPORT

CRAIGVILLE BEACH

HALL CREEK

SQUAW ISLAND

HYANNIS PT.

MATCH LINE - PLATE 4

CRAIG '72

SQUAW '72

N234,000

N233,000

N232,000

N231,000

N230,000

N229,000

E918,000

E919,000

E920,000

E921,000

E922,000

E923,000

E917,000

E916,000

S-1 S-2 S-3 S-4 S-5 S-6 S-7 S-8 S-9 S-10 S-11 S-12 S-13 S-14 S-15 S-16 S-17 S-18 S-20 S-21 S-22 S-23 S-24 S-25 S-26 S-27 S-28 S-29 S-30 S-31

1 2 3 4 5 6 7 8 9 10 11 12 13

NOTES:

Soundings and elevations are in feet and tenths and are referred to the plane of Mean Low Water.

Hydrography from survey of Jan. 18-Feb. 1, 1972 by E. Byram.

Topography from above survey and enlargement of C.&G.S. Chart 258.

B.M. 13 (1954) is a standard disk, unstamped, set in northwest corner of concrete base of public phone booth at northwest corner of Civic Assoc. dock house, at southeast corner of intersection of Iannaugh and Irving Aves. Elev. 10.44 ft. above M.L.W.

Coordinates are on the Lambert Grid System for the Comm. of Massachusetts.

Field books: R.B.H. 3181 & 3182.

Profile numbers shown thus: (31)

Beach sample material location shown thus S-27

SCALE IN FEET

200 0 200 400

BEACH EROSION CONTROL STUDY OF

SOUTH SHORE OF BARNSTABLE

BARNSTABLE, MASSACHUSETTS

PLAN OF BEACH PROFILES

NEW ENGLAND DIVISION, CORPS OF ENGINEERS

FEB. 1977

SHEET 1 OF 3

PLATE 3

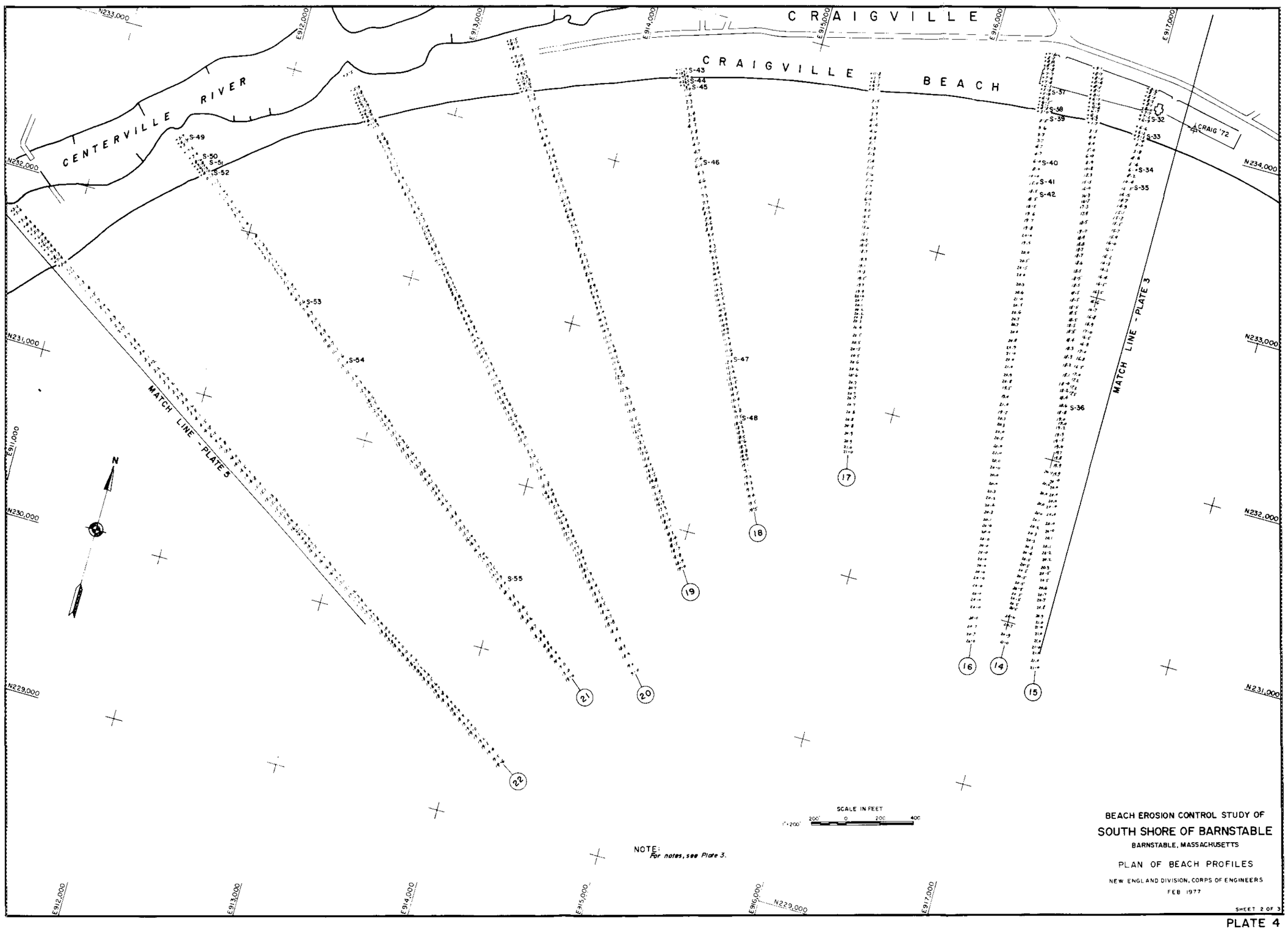
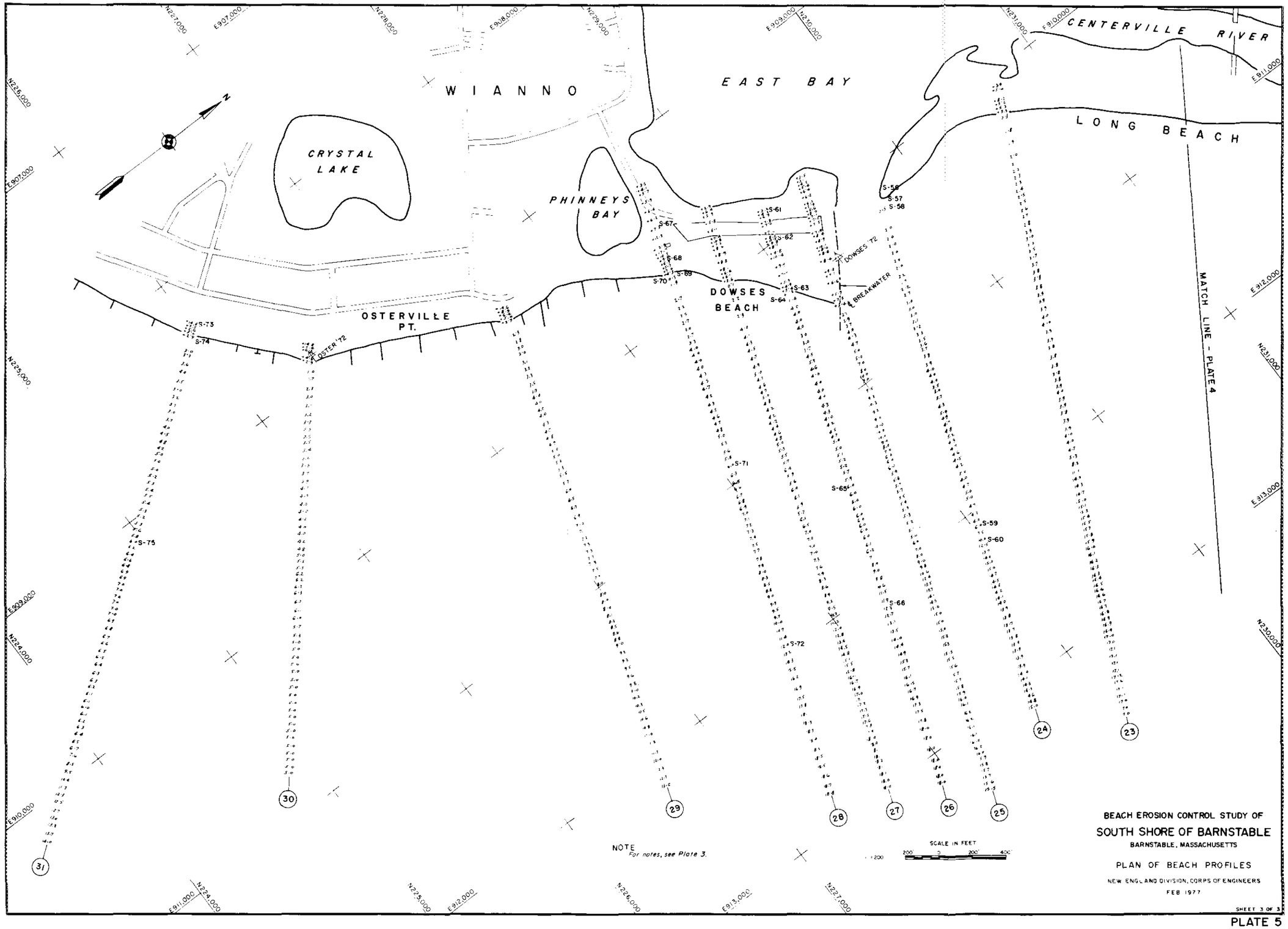

CRAIGVILLE
CRAIGVILLE BEACH
CENTERVILLE RIVER
CRAIG '72
MATCH LINE - PLATE 3
MATCH LINE - PLATE 3
N
S-32
S-33
S-34
S-35
S-36
S-37
S-38
S-39
S-40
S-41
S-42
S-43
S-44
S-45
S-46
S-47
S-48
S-49
S-50
S-51
S-52
S-53
S-54
S-55
17
18
19
20
21
22
16
14
15
N234,000
N233,000
N232,000
N231,000
N230,000
N229,000
E912,000
E913,000
E914,000
E915,000
E916,000
E917,000
E911,000
SCALE IN FEET
200' 0 200 400
1"=200'
NOTE:
For notes, see Plate 3.
BEACH EROSION CONTROL STUDY OF
SOUTH SHORE OF BARNSTABLE
BARNSTABLE, MASSACHUSETTS
PLAN OF BEACH PROFILES
NEW ENGLAND DIVISION, CORPS OF ENGINEERS
FEB 1977
SHEET 2 OF 3

PLATE 4



BEACH EROSION CONTROL STUDY OF

SOUTH SHORE OF BARNSTABLE

BARNSTABLE, MASSACHUSETTS

PLAN OF BEACH PROFILES

NEW ENGLAND DIVISION, CORPS OF ENGINEERS

FEB 1977

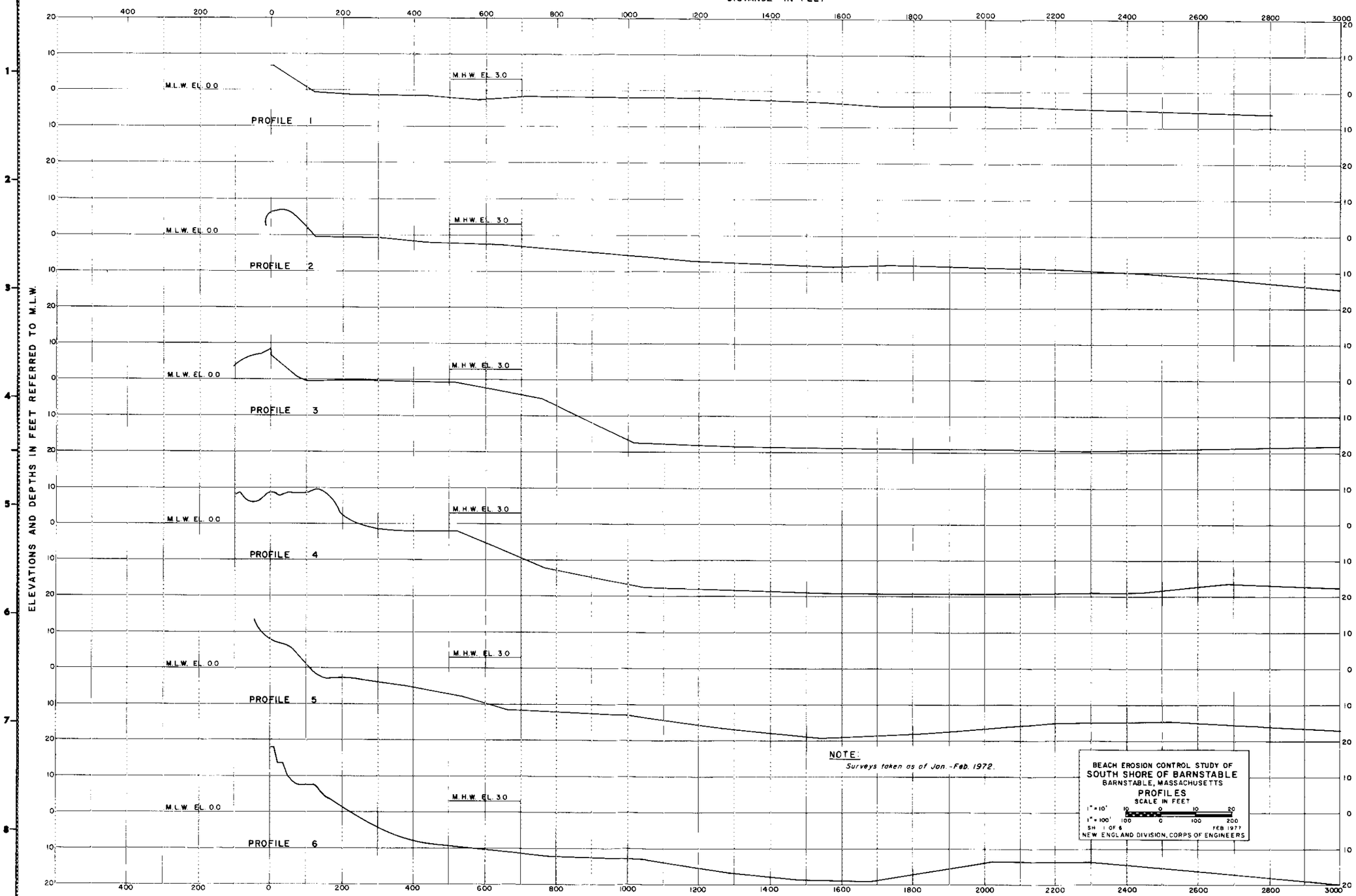
SHEET 3 OF 3

PLATE 5

CORPS OF ENGINEERS U. S ARMY

DISTANCE IN FEET

ELEVATIONS AND DEPTHS IN FEET REFERRED TO M.L.W.



NOTE:
Surveys taken as of Jan.-Feb. 1972.

BEACH EROSION CONTROL STUDY OF
SOUTH SHORE OF BARNSTABLE
BARNSTABLE, MASSACHUSETTS
PROFILES
SCALE IN FEET
1" = 10' 10 0 10 20
1" = 100' 100 0 100 200
SH 1 OF 6 FEB 1977
NEW ENGLAND DIVISION, CORPS OF ENGINEERS

PLATE 6

CORPS OF ENGINEERS U. S ARMY

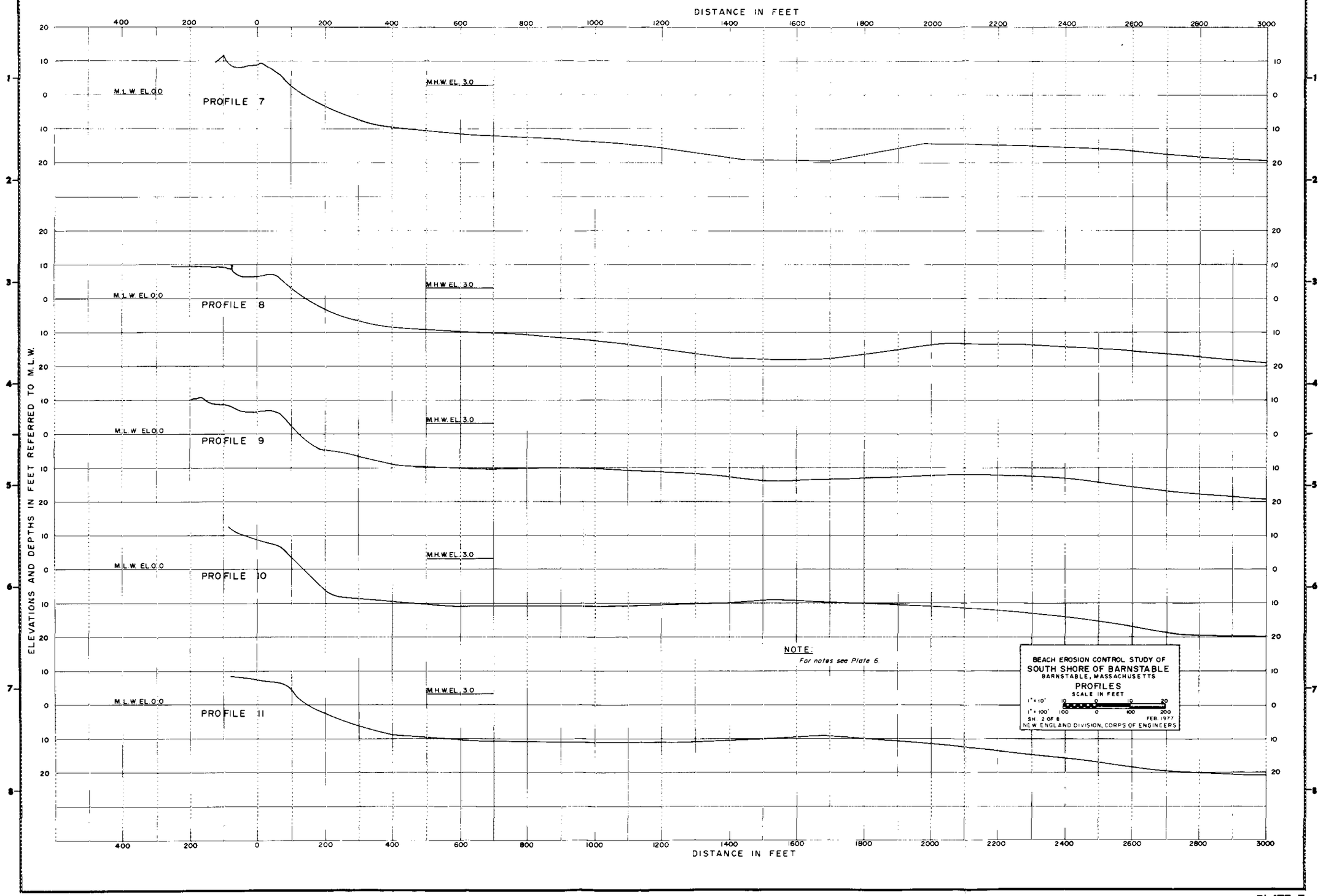


PLATE 7

CORPS OF ENGINEERS A B C D E F G H U. S ARMY

DISTANCE IN FEET

400 200 0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400 2600 2800 3000

ELEVATIONS AND DEPTHS IN FEET REFERRED TO M.L.W.

M.L.W. EL. 0.0 — PROFILE 12 — M.H.W. EL. 3.0

M.L.W. EL. 0.0 — PROFILE 13 — M.H.W. EL. 3.0

M.L.W. EL. 0.0 — PROFILE 14 — M.H.W. EL. 3.0

M.L.W. EL. 0.0 — PROFILE 15 — M.H.W. EL. 3.0

M.L.W. EL. 0.0 — PROFILE 16 — M.H.W. EL. 3.0

M.L.W. EL. 0.0 — PROFILE 17 — M.H.W. EL. 3.0

NOTE:
For notes see Plate 6.

BEACH EROSION CONTROL STUDY OF
SOUTH SHORE OF BARNSTABLE
BARNSTABLE, MASSACHUSETTS
PROFILES
SCALE IN FEET
1" = 10' 10 0 10 20
1" = 100' 100 0 100 200
SH. 3 OF 6 FEB. 1977
NEW ENGLAND DIVISION, CORPS OF ENGINEERS

DISTANCE IN FEET

PLATE 8

CORPS OF ENGINEERS U. S ARMY

DISTANCE IN FEET

PROFILE 18

PROFILE 19

PROFILE 20

PROFILE 21

PROFILE 22

PROFILE 23

M.L.W. EL 0.0

M.H.W. EL 3.0

ELEVATIONS AND DEPTHS IN FEET REFERRED TO M.L.W.

NOTE:
For notes see Plate 6.

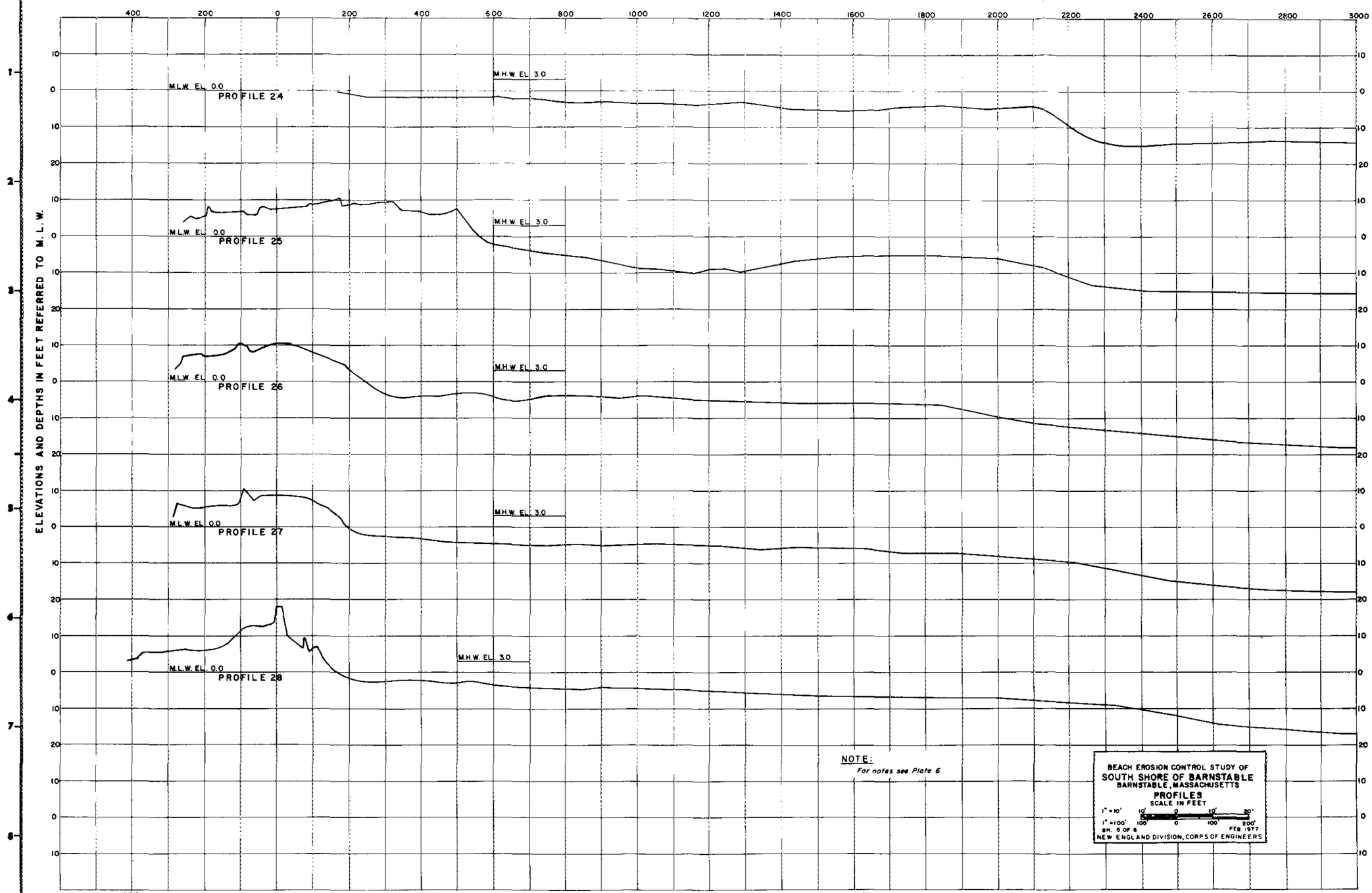
BEACH EROSION CONTROL STUDY OF
SOUTH SHORE OF BARNSTABLE
BARNSTABLE, MASSACHUSETTS
PROFILES
SCALE IN FEET
1" = 10' 10 0 10 20
1" = 100' 100 0 100 200
SH 4 OF 6 FEB. 1977
NEW ENGLAND DIVISION, CORPS OF ENGINEERS

PLATE 9

CORPS OF ENGINEERS U. S ARMY

DISTANCE IN FEET

ELEVATIONS AND DEPTHS IN FEET REFERRED TO M. L. W.



NOTE:
For notes see Plate 6.

BEACH EROSION CONTROL STUDY OF
SOUTH SHORE OF BARNSTABLE
BARNSTABLE, MASSACHUSETTS
PROFILES
SCALE IN FEET
1" = 10' 10' 0 10' 20'
1" = 100' 100' 0 100' 200'
SH. 6 OF 6 FEB. 1977
NEW ENGLAND DIVISION, CORPS OF ENGINEERS

DISTANCE IN FEET

PLATE 10

CORPS OF ENGINEERS U. S ARMY

DISTANCE IN FEET

400 200 0 200 400 600 800 1000 1200 1400 1600 1800 2000 2200 2400 2600 2800 3000

ELEVATIONS AND DEPTHS IN FEET REFERRED TO M.L.W.

M.L.W. EL. 0.0
PROFILE 29
M.H.W. EL. 3.0

M.L.W. EL. 0.0
PROFILE 30
M.H.W. EL. 3.0

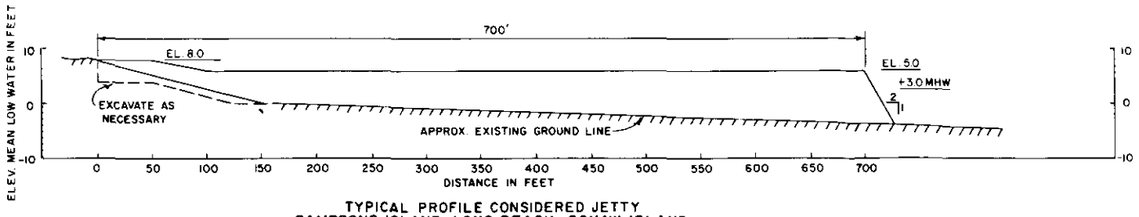
M.L.W. EL. 0.0
PROFILE 31
M.H.W. EL. 3.0

NOTE
For notes see Plate 6.

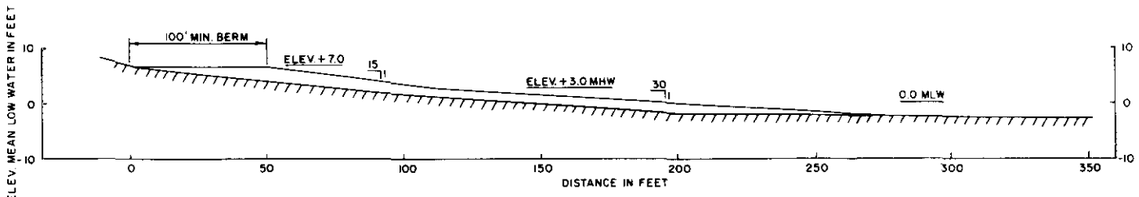
BEACH EROSION CONTROL STUDY OF
SOUTH SHORE OF BARNSTABLE
BARNSTABLE, MASSACHUSETTS
PROFILES
SCALE IN FEET
1" = 10' 10' 0 10' 20'
1" = 100' 100' 0 100' 200'
SH. 6 OF 6 FEB 1977
NEW ENGLAND DIVISION, CORPS OF ENGINEERS

DISTANCE IN FEET

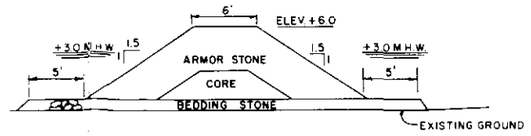
PLATE 11



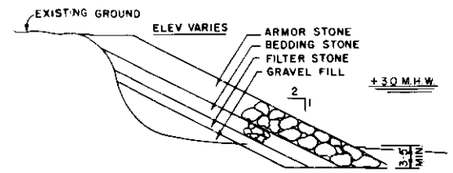
TYPICAL PROFILE CONSIDERED JETTY
SAMPSONS ISLAND, LONG BEACH, SQUAW ISLAND



TYPICAL PROFILE
BEACH WIDENING
OYSTER HARBORS AND LONG BEACHES

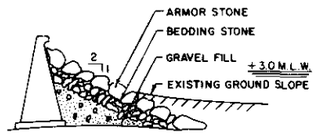


TYPICAL SECTION - CONSIDERED JETTY AT
SAMPSONS IS. - LONG BEACH - SQUAW IS.
SCALE 1" = 5'

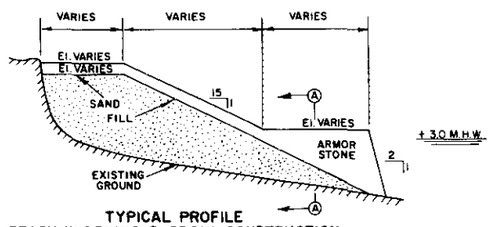


TYPICAL REVETMENT
DOWSES AND LONG BEACHES
NOT TO SCALE

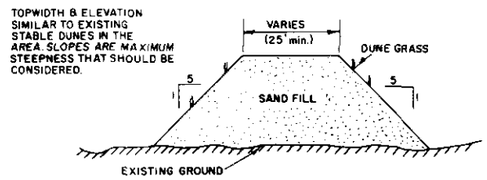
PLANS OF IMPROVEMENT FOR CONSIDERATION BY LOCAL INTERESTS



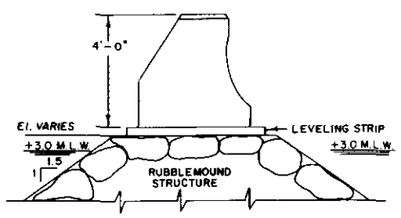
TYPICAL REVETMENT METHOD
(EXISTING STRUCTURES)
NOT TO SCALE



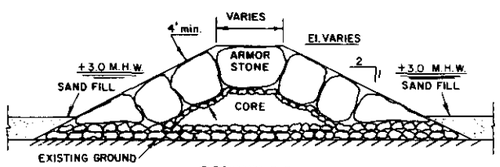
TYPICAL PROFILE
BEACH WIDENING & GROIN CONSTRUCTION
NOT TO SCALE



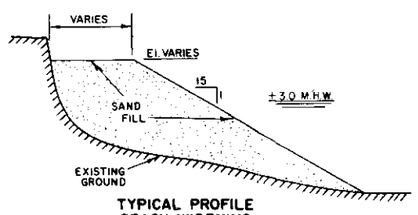
TYPICAL SECTION
DUNE RESTORATION
NOT TO SCALE



TYPICAL PRECAST CONCRETE SECTION
NOT TO SCALE



SECTION A-A
NOT TO SCALE



TYPICAL PROFILE
BEACH WIDENING
NOT TO SCALE

NOTES:

DISTANCES AND ELEVATIONS ARE IN FEET, DATUM IS MEAN LOW WATER.

BEACH EROSION CONTROL STUDY OF
SOUTH SHORE OF BARNSTABLE
BARNSTABLE, MASSACHUSETTS
PLANS OF PROTECTION
PROFILES - SECTIONS

NEW ENGLAND DIVISION, CORPS OF ENGINEERS
FEB 1977

METHODS OF EROSION CONTROL

PLATE 12

BEACH EROSION CONTROL STUDY OF SOUTH SHORE OF BARNSTABLE

STATE OF MASSACHUSETTS

SHORELINE AND OFFSHORE DEPTH CHANGES

POPPONESSET BAY TO LEWIS BAY

COASTAL ENGINEERING RESEARCH CENTER
FORT BELVOIR, VIRGINIA JUNE 1974

POLYCONIC PROJECTION DATUM NA 1927

SCALE IN FEET
2000 0 2000 4000 6000

LEGEND

HIGH WATER SHORELINE

1846	U.S.C.&G.S.
1890-91	"
1938-41	"
1961-62	"

DEPTH CURVES

	6FT	12FT	18FT	30FT
1847	— —	— —	— —	----------
1888	— —	— —	— —	----------
1939-42	— —	— —	— —	----------

COTUIT BAY
WEST BAY
EAST BAY
LEWIS BAY
POPPONESSET BAY

Centerville Church, 1845-934
M 28 QD, MGS
M 28 QC A, MGS
Hyannis Lighthouse, 1875
116B, MGS
Hyannis Breakwater, 1934
Pt Gammon Water Tower, 1934
Gammon, 1934
Great Rock Beacon, 1934
Pt Gammon Lighthouse, 1934
124 A, MGS, 1936
124 B, MGS
124 C, MGS
124 D, MGS
124 E, MGS
124 F, MGS
124 G, MGS
124 J, MGS, 1938
124 L, MGS
124 P, MGS
Hinkles WT, 1934
Maddens WT, 1934
Oyster Harbors Tank, 1934
Cotuitport Church Spire, 1887
Deems WT, 1934
Byrnes WT, 1934
Pierides WT, 1934
Beacon W Bay, 1934
Succonnesset, 1934

PLATE 13

APPENDICES

APPENDIX A
DESIGN CRITERIA
AND
DETAILED COST ESTIMATES

PREPARED BY THE
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
DEPARTMENT OF THE ARMY

[redacted]

[redacted]

[redacted]

APPENDIX A

Design Analysis

1. **DESIGN TIDE** - The design tide is the highest tide estimated to occur in the area on an average of once a year. The tide of 3.5 feet above mean high water was estimated as an average of the tides of record at Boston, Massachusetts and Newport, Rhode Island.

2. **DESIGN WAVE** - The height of design wave used for the jetties is the highest wave which can occur at the structure at the time of design high tide. Determination of this wave height was based on the limitations imposed by fetch, wind direction and speed, also by depths of water at the structure. Water depths limited the possible wave heights more than fetch distance or wind speed. Therefore, design wave height was computed using the solitary wave formula where the height of the wave is 0.78 times the depth at the structure at the height of the design tide.

3. **STONE SIZE** - The minimum weight of armor stone used in the jetties is determined by the formula:

$$W = \frac{W_r H^3}{K_D (Sr-1)^3} \text{ Cot } x$$

Where W = Weight of stone in pounds

W_r = Unit weight of stone in pounds/ft^3

K_D = A coefficient; 3.0 for the heads of structure and 3.2 for the trunks

S_r = Specific gravity = $\frac{\text{Unit weight of stone}}{\text{Unit weight of water}}$

x = Angle of slope of Structure to the horizontal plane

H = Design wave height at structure

The core or bedding stone immediately beneath the armor stone was designed to contain assorted sizes with at least one-half of the stone having weights equal to 10 percent of the armor stone weight. The top width of the jetties and the thickness of armor stone in revetments are at least twice the dimensions of a cube of stone having the specified weight of the armor stone. A lesser thickness of armor stone is sometimes necessitated due to the limited size of the structures.

Estimates of Costs of Improvement

1. **GENERAL** - A useful life of 50 years has been used in determining amortization charges. An annual interest rate of 6 3/8 percent has been used for the annual charges which are all non-Federal. Maintenance requirements for beach fills are based on maximum rates of loss determined from the past shore recession with a minimum rate of loss of one foot per year. It has been assumed that the jetties will reduce the rates of loss by 50 percent in areas near the jetty sites. Annual maintenance costs of jetties and revetments have been estimated as one percent of the first cost of construction.

2. **SAMPSONS ISLAND** - The plan of protection consists of a stone jetty 700 feet long at the western extremity of the island.

a. Total First Cost

Jetty Construction - 16,000 tons stone @ $ 22 =	$	352,000 *
Engineering & Design		60,000
Supervision & Administration		32,000
Total First Cost	$	444,000

* Includes Contingencies

b. Total Annual Charges

Interest	- 0.06375 x $ 444,000 =	$	28,300
Amortization	- 0.00303 x $ 444,000 =		1,350
Maintenance	- 160 tons @ $ 22.00 =		3,500
	Total Annual Charges	$	33,150

3. **OYSTER HARBOR BEACH** - The plan of protection and improvement consists of widening the beach by direct placement of sandfill for a distance of 2,000 feet west of the jetty at the entrance to West Bay.

a. Total First Cost

Beach Fill - 100,000 c.y. @ $ 3.50 =		$ 350,000
Contingencies		53,000
Engineering & Design		60,500
Supervision & Administration		36,300
Total First Cost		$ 499,800

b. Total Annual Charges

Interest - 0.06375 x $ 499,800 =		$ 31,900
Amortization - 0.00303 x $ 499,800 =		1,500
Maintenance - 12,600 c.y. @ $3.50 =		44,100
Total Annual Cost		$ 77,500

4. **DOWSES BEACH POINT** - The plan of protection consists of placement of riprap revetment from the inner end of the existing jetty to a point 800 feet inside the entrance to East Bay.

a. Total First Cost

Riprap revetment 11,000 tons @ $ 20 =		$ 220,000
Contingencies		33,000
Engineering & Design		45,500
Supervision & Administration		25,300
Total First Cost		$ 323,800

b. Total Annual Charges

Interest	- 0.06375 x $323,800 =	$ 20,600
Amortization	- 0.00303 x $325,800 =	1,000
Maintenance	110 tons @ $ 20 =	2,200
	Total Annual Charges	$ 23,800

5. **LONG BEACH** - The plan of protection consists of beach widening by direct placement of sand fill, construction of a jetty and riprap revetment along the shore from the jetty to East Bay a distance of 600 feet.

a. Total First Cost

Jetty Construction -	7,600 tons stone @ $22 =	$ 167,000
Riprap revetment -	8,500 tons stone @ $20 =	$ 170,000
Beach fill -	250,000 c.y. @ $ 3.50 =	$ 875,000
	Sub Total	$ 1,212,000
Contingencies		182,000
Engineering & Design		139,500
Supervision & Administration		98,000
	Total First Cost	$ 1,631,500

b. Total Annual Charges

Interest	- 0.06375 x $ 1,631,500 =	$ 104,000
Amortization	- 0.00303 x $ 1,631,500 =	4,900
Maintenance		
Jetty Repairs	76 Tons @ $ 22 =	$ 1,700
Revetment Repairs	85 Tons @ $ 20 =	1,700
Beach Fill	35,600 c.y. @ $ 3.50 =	124,600
	Total Annual Charges	$ 236,900

6. **SQUAW ISLAND** - The plan of protection consists of a jetty, 500 feet long, at the south side of the entrance to Hall Creek.

a. Total First Cost

Jetty Construction 8,000 Tons stone @ $ 22 =	$	176,000
Contingencies		26,000
Engineering & Design		34,400
Supervision & Administration		18,200
Total First Cost	$	254,600

b. Total Annual Charges

Interest - 0.06375 x $ 254,600 =	$	16,300
Amortization - 0.00303 x $ 254,600 =		700
Maintenance - 80 Tons @ $ 22 =		1,800
Total Annual Charges	$	18,800

APPENDIX B
LETTERS
OF
COMMENT

PREPARED BY THE
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
DEPARTMENT OF THE ARMY

Committee on Public Works

Congress of the United States
House of Representatives
Room 2165, Rayburn House Office Building
Washington, D.C. 20515

NED

APPENDIX B

DATE: February 28, 1969

SUBJECT: Town of Barnstable, Mass. and vicinity

REQUESTED BY: Rep. Hastings Keith

DOCKET NO.: 1708 Beach Erosion

Director of Civil Works
Office, Chief of Engineers
Washington, D. C. 20315

Dear Sir:

The Committee has been requested to adopt a resolution directing the Corps of Engineers to make a review study of the subject matter and would appreciate obtaining your views with particular reference to the desirability and justification of a study.

Any further information which would be of assistance to the Committee in determining whether the review should be authorized will be appreciated. It is requested that any attached papers submitted in support of this study be returned to the Committee along with your report.

Sincerely yours,

George H. Fallon

George H. Fallon, M. C.
Chairman

1708 DE

COMMITTEE ON PUBLIC WORKS
HOUSE OF REPRESENTATIVES, U.S.
WASHINGTON, D.C.

R E S O L U T I O N

Resolved by the Committee on Public Works of the House of Representatives, United States, that, in accordance with Section 110 of the River and Harbor Act of 1962, the Secretary of the Army is hereby requested to direct the Chief of Engineers, to make a survey of the shores of the Town of Barnstable, Massachusetts, in the interest of beach erosion control and related purposes.

Adopted December 11, 1969 George H. Fallon

Attest: .....
George H. Fallon, Chairman

(Requested by Rep. Hastings Keith)

Congress of the United States
House of Representatives
Room 2165, Rayburn House Office Building
Washington, D.C. 20515
TELEPHONE: AREA CODE 202, 225-4472

January 5, 1970

Chief of Engineers
Department of the Army
Washington, D. C. 20315

B.E. 1708

Dear Sir:

Enclosed is a resolution adopted by the Committee on Public Works directing the Corps of Engineers to proceed with a review investigation of the Town of Barnstable, Massachusetts, and vicinity.

Sincerely yours,

George H. Fallon

George H. Fallon, M. C.
Chairman

Incl 1

HIRSCHBERG/37215/je

ENGCW-PD

16 January 1970

Honorable George H. Fallon
Chairman, Committee on Public Works
House of Representatives
Washington, D. C. 20515

Dear Mr. Chairman:

Reference is made to your recent letter inclosing a resolution adopted by your Committee. This resolution requests that the Secretary of the Army cause to be made, under the direction of the Chief of Engineers, a survey of the shores of the Town of Barnstable, Massachusetts, in the interest of beach erosion control and related purposes.

The resolution is being referred to the appropriate office for action. This study will be initiated and report thereon rendered as soon as practicable; however, further action on this report is dependent on availability of funds from appropriations for surveys.

Sincerely yours,

LEONARD EDELSTEIN
Colonel, Corps of Engineers
Assistant Director of Civil Works
for Atlantic Divisions

CF: New England Div wd
River & Harbor Bd wd
Mr Hirschberg wd
Room 4-C-085

RETURN TO REPT PROC SEC - ENCCW-PD - ROOM 4-E-086

Encl 2

COMMITTEE ON
MERCHANT MARINE AND
FISHERIES

Congress of the United States

House of Representatives

Washington, D.C. 20515

February 19, 1969

FILE
1705
DOCKET

The Honorable George H. Fallon
Chairman, Committee on Public Works
House of Representatives
Washington, D. C. 20515

Dear Chairman Fallon:

I have been contacted by the Board of Selectmen of the Town of Barnstable, Massachusetts, evidencing a desire that a study be made by the Corps of Engineers to determine the most practical means of alleviating a most serious beach erosion problem on the town's south shore.

Therefore, it is respectfully requested that the Committee on Public Works adopt a resolution that the Board of Engineers for Rivers and Harbors be requested to review the report on Land and Water Resources of the United States, transmitted to the President of the United States by the Secretary of the Army on April 27, 1956, and subsequently published as Senate Document No. 14, 85th Congress. Such review to be made with a view to determining, in light of the heavy erosion process occurring along the South Shore of Cape Cod, the advisability of works improvement, particularly in the Town of Barnstable, Massachusetts, in the interest of beach erosion control, shore protection, navigation, and other allied water uses.

If you will keep me advised of your Committee's action in this matter, I will appreciate it.

Sincerely,

HASTINGS KEITH
Member of Congress

HK:EBS

Town of Barnstable

Selectmen's Office

Hyannis, Mass. 02601

January 31, 1969

Congressman Hastings Keith
243 Post Office Building
New Bedford, Massachusetts

Dear Congressman Keith:

The Town of Barnstable is experiencing serious beach erosion on our South Shore and we would like to have you offer to Congress a Resolution to have the U.S. Corp. of Engineers survey this problem and determine the best methods to eleviate the cost.

I hope that I have worded this properly and if there is any further information you need I would be most happy to forward it.

Very truly yours,

George L. Cross

George L. Cross, Chairman
Board of Selectmen

GLC:bsr

SR-1
INFORMATION CALLED FOR BY SENATE RESOLUTION 148, 85 CONGRESS ADOPTED 28 JANUARY 1958

PREPARED BY THE
NEW ENGLAND DIVISION
CORPS OF ENGINEERS
DEPARTMENT OF THE ARMY

SR-1

BEACH EROSION CONTROL REPORT ON SOUTH SHORE

OF BARNSTABLE, MASSACHUSETTS

INFORMATION CALLED FOR BY SENATE RESOLUTION 148,

85 TH CONGRESS, ADOPTED 28 JANUARY 1958

1. The study covers the south shore of Barnstable, Massachusetts, between Popponesset Bay and Hyannis Harbor. The problem consists of erosion of beaches and coastal shorelines from wave attack. The shore is exposed to wave attack from the Atlantic Ocean across Nantucket Sound through limited openings between the offshore islands of Martha's Vineyard and Nantucket. The mean range of tide varies from 2.3 to 3.1 feet. The highest tide of record of 12.5 feet above mean low water occurred at Hyannis Harbor during 14-15 September 1944.

2. **IMPROVEMENTS CONSIDERED** - Plans were developed for protection and restoration of shore areas as follows:

a. Sampsons Island - Construct a stone jetty at the western tip of the island to trap littoral drift of sand from passing into the entrance of Cotuit Bay.

b. Oyster Harbors Beach - Widen 2,000 feet of beach by direct placement of sand fill to prevent flanking of the existing jetty at the entrance to West Bay by storms.

c. Dowses Beach - Riprap revetment at the eastern end of the beach to stablize the shoreline on the East Bay side of the beach.

d. Long Beach - Widen 4,000 feet of beach by direct placement of sand fill on the Nantucket Sound side; also, placement of sand fill in two narrow portions of the beach on the Centerville River

side; construct a stone jetty on the east side of the entrance to East Bay; riprap revetment at the western end of the beach to stablize the shore line facing the entrance to East Bay.

e. Squaw Island - Construct a stone jetty at the entrance to Hall Creek to trap sand along the westerly side of the Island.

In addition, general methods of protection and improvements where considered for other areas which did not merit development of detailed plans. These methods consisted of maintenance of existing protective structures, construction of additional seawalls, groins and revetment where needed for future development, placement of stockpiles of sand along the shore to nourish beaches. Complete protection of low areas by high seawalls or other barriers is not warranted by the benefits which would be derived from protection.

3. **CONCLUSIONS AND RECOMMENDATIONS** - The adequacy of public beach areas for present recreational use and the lack of space to expand parking facilities for prospective increased use result in insufficient benefits to warrant Federal participation in development of an improvement. In view of the private ownership of property where plans were considered, public interest, as required by Federal laws, is insufficient to permit participation. Therefore, it was recommended that no projects be adopted by the United States for the protection or improvement of the south shore of Barnstable, Massachusetts. It was further recommended that protective measures which may be undertaken by local interests, based upon their determination of economic and environmental justification, be accomplished in accordance with plans and methods considered in the study.

Estimated first costs of considered improvements all non-Federal, are listed as follows:

Location	Improvement	Estimated First Cost
Sampsons Island	Stone Jetty	$ 444,000
Oyster Harbor Beach	Sand Fill	499,800
Dowses Beach	Revetment	323,800
Long Beach	Stone Jetty, Revetment, Sand Fill	1,631,500
Squaw Island	Stone Jetty	254,600

4. **DISCUSSION** - The economic justification for construction of the considered projects has not been determined. Benefits were not evaluated since benefits to be derived are principally private and are not of a type to make the improvements eligible for Federal aid under existing Federal policy. Changing the economic life of the considered projects would not change the findings of the study in so far as they pertain to eligibility for Federal aid.